

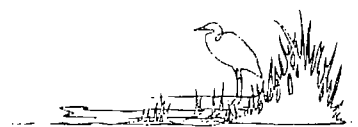
**BRUNSWICK COMMUNITY BASED  
ENVIRONMENTAL PROTECTION STUDY**

CHARACTERIZATION AND SPATIAL DISTRIBUTION  
OF CONTAMINANTS IN  
SURFACE WATER, SEDIMENTS AND FISH  
WITHIN THE TIDAL REACHES SURROUNDING  
BRUNSWICK, GEORGIA



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## EXECUTIVE SUMMARY

The study included analyses for metals, extractable organic compounds, purgeable organic compounds and PCB/pesticides in surface water and sediment samples in the tidally influenced surface water areas surrounding the city of Brunswick, Georgia. The study included two components; (1) River areas, which include all of the surrounding rivers and tidal creeks and (2) Marsh areas, which include all of the associated salt marshes adjacent to the rivers and tidal creeks. Selected river sediment stations were analyzed for dioxins. Only sediments were collected at the marsh sampling stations and were analyzed for metals, extractable organic compounds, purgeable organic compounds and PCB/pesticides. Fish were collected at selected river sampling stations and analyzed for metals, extractable organic compounds and PCB's/pesticides.

Stations were randomly selected by computer utilizing an EMAP approach, wherein each station has a weighting value which represents a certain amount of surface area within the selected study area. Cumulative Distribution Frequency (CDF) curves can then be developed which compare the concentrations of a constituent to the percentage of surface area within the study area where the constituent is found. Metals analysis in river and marsh sediments provided the vast majority of concentration values above detectable limits, therefore CDF curves were only generated for metals concentrations and aroclor 1268 concentrations in river and marsh sediments. Following is a synopsis of the results:

### Surface Water

Analyses of surface water samples revealed most constituents to generally be below analytical detection limits. Low level mercury analysis revealed a grouping of higher values ( $> 8.0$  ng/l) on the upper end of the Turtle River (Figure 1 and 13). Station 49 in Terry Creek on the east side of Brunswick contained low concentrations of purgeable organic compounds not detected at other stations such as chloroform, carbon tetrachloride, and methyl isobutyl ketone.

### Sediments

River sediment samples from station 48 and marsh sediment samples from stations 32, 38 and 49, contained high levels of mercury, i.e. greater than the Effective Range-Median (ER-M)<sup>1</sup> value of .71 mg/kg. The concentrations at these stations, which are in general proximity to each other to the west of Brunswick and in the vicinity of LCP chemical, ranges from .89 mg/kg to a high of 14.0 mg/kg of mercury. CDF curves indicate that approximately 3 percent of the river and 4 percent of the marsh have mercury concentrations greater than the ER-M value. Sediment samples from station 49 in the marsh, which is adjacent to Academy Creek on the west side of the city of Brunswick, contained significantly higher values for lead (120 mg/kg), copper (130 mg/kg) and especially zinc (530 mg/kg), than the other marsh stations. With a concentration of 530 mg/kg, the zinc concentration at station 49 was the only other metal besides mercury to exceed the ER-M value (410 mg/kg). Station 49 in the river

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<sup>1</sup>Long, Edward R., Donald D. MacDonald, and Sherri L. Smith. 1994. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management.

## EXECUTIVE SUMMARY (Continued)

sediments contained significantly higher concentrations of lead (120 mg/kg) and zinc (170 mg/kg), than the other river stations. Concentrations of all other metals ranged between the detection limits and the ER-M values.

Samples from station 49 in the river and stations 49 and 77 in the marsh contained more organic compounds than other stations, fourteen and eight respectively. With the exception of non-toxic fatty acids normally found in fish tissues and other organic material, only scattered low concentrations of various other organic compounds were detected. Station 4 had an unexplainably high concentration of kaurenoic acid (200,000 ug/kg). This was the only station where this compound occurred.

Very few purgeable organic compounds were detected in either the river or marsh sediments. Low concentrations of acetone were detected at three river stations and low concentrations of thiobismethane were detected at 17 marsh stations.

The only PCB detected in sediments was aroclor 1268. There were relatively high concentrations of aroclor 1268 at river station 48 (1400ug/kg) and 69 (5200 ug/kg), and in marsh station 38 (4200 ug/kg). These stations are in the general vicinity of each other on the west side of Brunswick, near LCP Chemical. CDF curves indicate concentrations are below 100 ug/kg in approximately 80 percent of the remainder of the study area.

Dioxins/furans were analyzed for in sediments at 14 river stations. 2,3,7,8 tetrachlorodibenzodioxin (TCDD), the most toxic dioxin isomer, was detected at stations 8, 30, 32, 41 and 48 with concentrations ranging from 1.1 to 4.0 ng/kg. Stations 8, 32 and 48 are on the west side of Brunswick, north of Andrews Island and south of LCP Chemical. Station 30 is at the mouth of Terry Creek on the east side of Brunswick and station 41 is located in Jekyll Creek south of St. Simons Sound. Toxic equivalent values (TEQs) ranged from 0 to 18 ng/kg with the stations containing TCDD having the highest values (10-18 ng/kg).

### Fish

The mummichog *Fundulus heteroclitus*, was collected at 24 of the 81 river stations and analyzed for metals, PCBs/Pesticides and extractable organic compounds. Station 55, located near the mouth of the South Brunswick River, contained high levels of chromium (1.7 mg/kg). Other metals analyses revealed either low concentrations, or there was no comparative data.

Toxaphene was the only pesticide detected in fish. It was detected in duplicate samples taken from station 49 (Terry Creek), with concentrations of 19 and 27 mg/kg. Due to the toxic nature of toxaphene, this may be cause for further investigation at this site.

Non-toxic fatty acids normally found in fish tissue were the only extractable organic compounds detected.



## 1.0 INTRODUCTION

In December 1995 and in April 1996, as part of the Brunswick, Georgia Community Based Environmental Protection Study and at the request of the Waste Management Division, Region IV, the Science and Ecosystem Support Division (SESD), Ecological Assessment Branch (EAB) with assistance from the Enforcement and Investigations Branch (EIB) conducted a survey of the entire tidally influenced surface water and marsh areas surrounding the City of Brunswick.

The primary objective of the study was to characterize the spatial distribution and concentrations of chemical constituents within the tidal reaches of the study area. The surface water study area encompassed the Turtle River, the Brunswick River, the South Brunswick River, the East River, the Back River, the Frederica River and the Mackay River, as well as the adjacent tidal creeks. These various river systems will henceforth in this report be collectively referred to as 'river stations', unless otherwise noted. The 'marsh stations' refers to the sampling stations within the salt marshes adjacent to the above mentioned rivers. Chemical characterization efforts focused upon tidal surface water within the rivers, sediments in the rivers and the marsh and selected ecological indicators associated with the aquatic resources of the study area. Eighty-one sampling stations were randomly selected in the surface water areas and eighty sampling stations were randomly selected in the marsh areas utilizing EPA's Environmental Monitoring and Assessment Program (EMAP) approach (Overton, et al., 1992). Stations within the surface water and marsh areas were sampled and analyzed for the Target Analyte List (TAL) and Target Compound List (TCL) constituents (Table 4 and 5). Because an EMAP approach was utilized for station locations, cumulative distribution frequency (CDF) curves, which compare the concentrations of a constituent to the percentage of surface area within the study boundaries can be developed. The CDF curves coupled with GIS analysis give an indication of the areal extent of a particular constituent within the study boundaries. Metals analysis in river and marsh sediments provided the vast majority of concentration values above detectable limits, therefore CDF curves were only generated for metals and the PCB, aroclor 1268, found in river and marsh sediments (Graphs 20-35).

Once the analytical data was received from the lab, it was entered into SESD's Geographical Information System (GIS). Maps were then generated to indicate the spatial distribution as well as gradients of chemical constituents within the system. Figures were primarily generated for metals concentrations in sediment and fish as well as the Polychlorinated Biphenyl (PCB), Aroclor 1268 and dioxins/furans in sediments. Observed metal concentrations in sediment samples collected at Brunswick were also compared with regional concentrations for significance with an analysis of variance (ANOVA) at the  $\alpha = 0.05$  or the 95% confidence level.

## 2.0 STUDY DESIGN

For sediments and surface water, the study approach involved a randomized sampling design. This design provided the basis for statistically establishing representative estimates of concentration and areal distribution of chemicals of concern in the tidal reaches of the study area. Using a probabilistic sampling design provided by the EMAP program of EPA, eighty sampling stations were randomly selected for the tidal marsh and eighty one stations were selected for the rivers, including their associated tidal creeks. Spacial distribution of the stations are shown in Figures 1, 2 and 3. Their geographical positions are provided in Tables 1 and 2. The project was divided into four phases. Phase one through three were completed November 27th through December 8th, 1995 and phase four was completed April 21-24, 1996.

### 2.1 Phase I - Surface Water Sampling

Phase I of the study involved collection of surface water samples from the surrounding rivers. Eighty-one stations were assigned to the rivers and associated tidal streams within the study area. These stations were separated into two sampling events, spatially distributed throughout the study area. Each sampling event was scheduled on a different day but on a similar tidal amplitude of the flood tide, due to the logistical problems associated with sampling a large number of stations concurrently. Sampling within each river segment occurred synoptically during the specified window of the tidal phase. Sampling of each surface water segment yielded approximately 40 water samples for analyses of the TAL and TCL constituents as well as for ultra trace levels of total mercury.

### 2.2 Phase II - River Sediment Sampling

Phase II of the study involved sampling sediments associated with the same stations identified in the surface water sampling but the sediments were not sampled synoptically with the tidal cycle. All sediment samples were analyzed for the TAL and TCL constituents, particle size was determined and dioxins were analyzed at selected stations.

### 2.3 Phase III - Biological (Fish) Sampling

Phase III of the sampling agenda involved collection of fish to help understand the extent and magnitude of contamination within the study area's tidal reaches. The mummichog, Fundulus heteroclitis, a killifish species, was chosen as the target species due to its ubiquitous distribution and importance in the marsh food chain. Fish were collected at 24 sampling stations (Figure 3). Composite whole-fish samples were prepared and submitted for TCL (other than volatile organic compounds) and TAL analyses.

## 2.4 Phase IV - Tidal Marsh Sediment Sampling

Phase IV of the sampling involved the tidal marsh areas of the study area and was completed in April 1996. Marsh sediments at each of the designated stations were sampled utilizing a helicopter with floats or with a boat at stations located adjacent to open water. Sediment samples were collected and analyzed for TAL and TCL constituents.

## **3.0 SAMPLING TASKS AND METHODS**

Water, sediment and biological sampling activities during Phases I, II and III were completed with assistance from the EPA Ocean Survey Vessel, Peter W. Anderson. The ship complimented survey activities by serving as the communication center and primary staging area for on-site mobilization of water, sediment, and fish sampling. Six to seven smaller watercraft operated from the ship during the tidal phased water quality sampling as well as during the river sediment and biological efforts. Shipboard laboratory facilities functioned as preliminary sample handling, processing, and storage facilities. Diving activities, likewise, depended upon the ship's logistical support.

Only sediments were sampled in the marsh areas. A helicopter with floats was utilized for access to most of the 80 marsh stations because ambulatory access to marsh stations would have been difficult and potentially dangerous due to the extreme tidal range in the Brunswick area and a boat would have been unable to get through the marsh vegetation. Stations located adjacent to open water on the marsh/open water fringe were sampled by boat to minimize helicopter operating time and associated costs.

### 3.1 Surface Water Sampling

Surface water stations were sampled during slack high tide. This tidal phase was selected to allow maximum access to the upper reaches of the tidal creeks. To establish this sampling window, water level recorders were installed in the study area. Records from these recorders coupled with information from local National Ocean Survey (NOS) tide tables were used to predict the probable slack high tide periods for the sampling stations. Six field crews were staged throughout the study area and assigned an array of sites to be sampled in a designated sequence within a specified time window to help assure that all stations were sampled on approximately the same tidal stage. Because all eighty-one stations could not be sampled on one tidal cycle, half the stations were sampled on November 29th, and the other half were sampled on December 6th. All stations needed to be sampled on approximately the same tidal amplitude in order to duplicate the sampling regime as closely as possible. The closest date with approximately the same tidal amplitude as November 29th was December 6th, thus the delay between sampling of the first half of the stations and the sampling of the second half of the stations. Prior to the scheduled sampling effort, many stations along the marsh fringe were located with Global Positioning System (GPS) units and flagged to reduce navigation time during sampling. Representative stations were surveyed to determine if the water column was

stratified vertically due to variation in density. For purposes of sampling, the water column was considered to be in a fully mixed condition if salinity varied less than five parts per thousand (PPT) from surface to bottom. In the fully mixed condition, surface water grab samples were considered representative of the station. Based on this preliminary *in situ* sampling, all stations were considered fully mixed. Because the stations were considered equally mixed, no *in situ* water quality parameters were measured during the sampling effort. Samples were collected in appropriate containers and handled per standard operating procedures (US-EPA, 1991). Data Quality Objectives for surface water samples are provided in Table 6.

### 3.2 River Sediment Sampling

At each of the surface water stations, 2-3 replicate sediment samples (as required for adequate sample volume) were collected with either a coring or dredging device. Deep water sediment samples were collected by EPA SCUBA divers using stainless steel or teflon coring tubes. Samples from shallow water areas were collected using either coring tubes or a dredge. The depth of the bottom substrate sampled was restricted to approximately the top 15 centimeters (cm). Samples for volatile organic compound analysis were collected by divers in a four ounce septum-sealed glass container filled with laboratory deionized water. The container was opened for sampling, and sealed upon obtaining the sample, by the diver while under water.

Replicate samples were placed in a Standard Operating Procedure (SOP) cleaned glass pan and composited, with the exception of the volatile organic samples, which were treated as described above. Sub-samples of this composite were analyzed for the TAL/TCL constituents, sediment particle size, and total organic content according to methods identified in the SEDS standard operating procedures (US-EPA 1990, US-EPA, 1991).

In addition to samples collected for particle size analyses at the designated river sample points, additional samples were collected for particle size analyses at points along transect lines. This was done in an attempt to map particle size distribution and then to correlate analytical results with sediment particle size. Particle size samples were collected at quarter points along a line transect extending perpendicular to the river flow and through the original designated sampling stations. At each quarter point along the transect, a grab sediment sample was collected for particle size analysis. Depth of penetration for particle size samples was approximately the top 15 centimeters of sediment.

Exploratory ANOVA statistical procedures were used to compare physical characteristics and sediment chemistry between stations. Comparisons were made between high, medium, and low chemical concentrations within the fine and coarse soil fractions. Data Quality Objectives for sediment samples are located in Table 6.

### 3.3 Tidal Marsh Sediment Sampling

Only sediments were collected at marsh stations and were analyzed for TAL/TCL constituents. Due to the daily six to eight foot tidal range, the salt marshes around Brunswick are inundated for brief periods twice daily. Therefore sampling water in the marsh was deemed inappropriate because the water that is inundating a station has a very short residence time and can be represented by the water found in the adjacent tidal creeks.

Due to the spatial distribution, time, effort and potential danger to personnel, a Bell Jet Ranger helicopter with floats, owned by the National Fish and Wildlife Service was leased to conduct the Brunswick marsh sampling. The helicopter greatly expedited this phase of sampling, allowing all of the marsh sampling to be completed in four days with only six personnel. A boat was also utilized to sample stations adjacent to open water along the marsh edge. The Georgia Department of Natural Resources/Department of Environmental Protection Field Office served as the base of operations for the marsh sampling. The United States Coast Guard provided flight following communications for the helicopter. The Helicopter pilot would check in with Coast Guard Dispatch each time the helicopter landed or took off to insure a speedy rescue in the unlikely event of an accident. Due to the limited space on board the helicopter and the inability to decontaminate bulky equipment during flight operations, marsh sediment samples were collected with stainless steel spoons, by digging a hole on site and mixing in the hole. Thick dense root mats in some locations prevented collecting samples of sufficient depth. In this situation, surface sediment was composited and mixed on the sediment surface. An unmixed grab sample was used for volatile organic analysis. Samples were analyzed for TAL/TCL constituents. Sampling of marsh sediments was not tidal stage dependent as was the case with surface water sampling. However, tidal stage information was utilized to facilitate helicopter or boat access to the fringe and interior marsh stations.

### 3.4 Biological (Fish) Sampling

The focus of the aquatic biota sampling was the mummichog, Fundulus heteroclitis, a killifish species. The mummichog was chosen due to its significance in the marsh food chain, its territoriality and its ubiquitous distribution within the marsh system. F. heteroclitis was collected on falling tides at the mouths of small tidal creeks at the creek's discharge point from the marsh. Minnow traps attached to a stake and orientated with the water flow provided the best results. Composite whole-fish samples were prepared (US-EPA, 1993a) and submitted for TCL and TAL analysis.

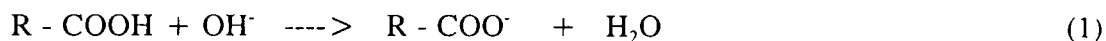
Data quality objectives for fish sampling activities for this project are listed in Table 6.

#### 4.0 DISCUSSION AND RESULTS

Estuaries form the interface between freshwater and marine water. Dramatic changes in conductivity, salinity, pH, and sometimes, temperature occur along this dynamic gradient. Consequently, several biogeochemical processes in estuaries are possible including flocculation, dissolution of particulates, biological assimilation and mineralization, and sorption of elements and compounds by clay particles and organic matter (Stumm and Morgan 1981). For most coastal areas, and the Southern United States in particular, natural trace metal concentrations can vary widely. This is influenced for the most part by the type of base material that the sediments are generated from and the particle size. A coarse sandy or silicate material typically has much lower concentrations of trace metals than very fine clay fractions called aluminosilicates or phyllosilicates. Compounds critical in biogeochemical processes such as sulfates and carbonates are provided by incoming marine waters, whereas, nutrients, organic carbon, silicon (in the form of phyllosilicates), and iron come from out-flowing rivers and associated wetland systems. Phyllosilicates are clay minerals composed of silicon, aluminum, and other earth metals and bases such as magnesium, calcium, sodium, and potassium. Common phyllosilicates are mica, chlorite, talc, kaolinite, smectite, and vermiculite. They are predominantly found in the clay fraction ( $<2\mu\text{m}$ ) of most soils and sediments. In addition, phyllosilicates are common colloids (or suspended solids) in the water column of riverine and estuarine ecosystems. Given the small size (thus high surface area) and cation exchange properties of phyllosilicates, their presence is conducive to absorption and adsorption of metals from natural and anthropogenic sources.

In general, phyllosilicates exhibit a net negative charge, and consequently, have a high affinity for cations such as heavy metals. The capacity of phyllosilicates to sequester heavy metals is dependent on their permanent and variable charge (Mitsch and Gosselink 1993, Stumm and Morgan 1981, and Tisdale et al. 1985). The cation exchange capacity (CEC) is a measure of this ability. However, if the cation concentration exceeds the CEC, excess cations remain in solution in the pore water or the water column. Estuarine environments tend to function as metals and contaminant sinks for both natural and anthropogenic sources due to positively charged metal ions in the water column precipitating out when they reach the higher pH's of the estuarine waters and are bound up by the negatively charged phyllosilicate clay particles in the estuarine sediments. This is particularly true in the anaerobic salt marsh sediments, which normally have very reduced conditions, high sediment pH, and therefore, a very strong affinity for metals. Due to the variability in sediment particle size, and accompanying metal binding capability, data results can be confusing. It is helpful to have a method of normalizing the data. In past studies conducted by the Ecological Assessment Branch, the relationship of particle size and/or organic matter to metals concentration has been utilized to help normalize results. Organic matter plays an important role in sequestration of metals. Function groups on organic particles responsible for the predominance of metal removal are phenolic and carbonylic side chains. In contrast to permanent charge exhibited by many clay minerals, organic carbon chains exhibit variable or pH-dependent charge. In general, the higher the pH of the surrounding water, the higher the hydroxyl ( $\text{OH}^-$ ) concentration, consequently, the more

likely the organic carbon chain will have a net negative charge:



The freshwater-marine water interface of the Georgia coast provides an excellent medium for this reaction to occur: organic carbon compounds carried by acidic, blackwater rivers merges with alkaline, marine waters.

In the Brunswick Study, a modified grain size analysis in which different sediment size fractions were combined in an attempt to deal with the volume of samples and the enormous amount of time involved in sample preparations and analysis, was conducted. Clays, silts and very fine sands were composited in one fraction called "fine" material. Everything larger than very fine sands was composited into a fraction called "coarse" material. This method resulted in less of a correlation with the fine material than would normally be expected due to the clay fraction being lumped together with coarser grain sizes, although there was still a strong correlation with metals to organic matter content (Graphs 13-19).

As mentioned above, metals have a strong association with phyllosilicate clay particles. Due to this association, along with the fact that aluminum is the second most abundant metal in the earth's crust, aluminum has been utilized in several studies to normalize data (Noakes, 1994, Windom, et al., 1987, Windom, et al., 1989). In A GUIDE TO THE INTERPRETATION OF METAL CONCENTRATIONS IN ESTUARINE SEDIMENTS, (Windom, 1987), uncontaminated estuarine sediments were collected from the Georgia and Florida coasts. Samples were analyzed, and aluminum vs. metals concentrations were developed using log transformed data. From these correlations, regional regression curves were developed utilizing the aluminum versus metals concentration ratios. These curves represent the normal aluminum to metals ratios found in the Southeast. Therefore if a metals concentration at a particular station is located above the 95% confidence bands, then there is a high probability that the concentration is from an anthropogenic source. Concentrations located within or below the 95% confidence bands can be considered within the normal range for the Southeast. Two exceptions to this technique are mercury and cadmium which do not seem to have a good correlation with aluminum. This methodology was utilized to normalize the Brunswick metals data and indicates that the majority of metal concentrations in the study area are within the normal regional levels (graphs 1-12). Sample stations are located on Figures 1, 2 and 3.

#### 4.1 Surface Water Sampling Results

Very few contaminants of concern were detected in the water column. Most of the constituents evaluated in this study were below sample detection limits. Exceptions to this were the low level mercury analysis and some purgeable organic compounds. The only noticeable trend in the water column data was the low level mercury analysis.

#### 4.1.1 Surface Water Metals

Except for base metals such as strontium, aluminum, calcium, magnesium, iron, sodium, and potassium, no other metals were detected (Appendix A-1). Low level mercury was a separate analysis and was detected at ranges of 2-11 ng/l (Figure 13). Higher concentrations of mercury, ( $> 8$  ng/l), were grouped on the upper end of the Turtle River, (Figure 13). Since sampling occurred on the high tide, this would indicate that these higher concentrations of mercury were being pushed upstream by the tide from an anthropogenic source downstream.

#### 4.1.2 Surface Water PCB's/Pesticides

The only detectable PCB/Pesticide constituent was gamma-chlordane at station 48 (.0066 ug/l) and station 50 (.0072 ug/l) (Figure 1). All other constituents were below detection limits (Appendix A-2).

#### 4.1.3 Surface Water Extractable Organic Compounds

Except for low concentrations of bis (2-ethylhexyl) phthalate at stations 3 (240 ug/l) and 16 (16 ug/l) and naphthalene at station 72 (1.1 ug/l) (Figure 1), all other compounds were below sample detection limits (Appendix A-3).

#### 4.1.4 Surface Water Purgeable Organic Compounds

Several purgeable organic compounds were detected, although at very low concentrations (Appendix A-4). Stations 6, 16, 19, 20, 21, and 23 contained toluene at levels below 2 ug/l. All of these stations except station 6 also contained (m- and/or p-) xylene at concentrations of approximately 1.0 ug/l. Station 21 contained 1,2,4-trimethylbenzene at 0.51 ug/l. Station 11 contained methyl butyl ketone (1.9 ug/l) and methyl isobutyl ketone (2.2 ug/l). Station 31 contained carbon disulfide at 1.5 ug/l. Station 49 contained methyl isobutyl ketone (6.7 ug/l), chloroform (2.0 ug/l) and carbon Tetrachloride (1.4 ug/l).

#### 4.2 Sediment Sampling Results

The highest concentrations of analytes were metals in sediments, both in the river sediments and the marsh sediments (Appendix B-1, C-1). As expected, the marsh contained higher concentrations than the river (Figures 4-17). This indicates that the salt marshes are serving the function of filters, binding and storing contaminants, therefore protecting the surface estuarine waters of the Brunswick area. In the PCB/Pesticides data set, only Aroclor 1268 was found in the sediments.



#### 4.2.1 Sediment Metals

Metals data were plotted in relation to Region 4's Waste Management Division's (WD) Screening Values (US-EPA, 1994) and NOAA's Effective Range-Median, (ER-M 94) values (Long, et al. 1994). The WD screening values are based primarily on the No Observable Effects Limit (NOEL 93) values (MacDonald, 1993), that is, values at which there were no toxic effects to test organisms observed in acute toxicity tests. The ER-M values represent the median range of toxicity values, based on many different toxicity tests of marine sediments around the U.S. during which, at concentrations above this value, effects were frequently or always observed in acute toxicity tests (Long, et al., 1991). The range of values plotted for the GIS generated figures are: (1) below sample detection limits; (2) detectable values up to the WD screening value (non toxic); (3) the WD screening value up to the ER-M value (slightly to moderately toxic) and (4) greater than the ER-M value (highly toxic). Again, the term "toxicity" as used here, is based on tests of marine test organisms in laboratory controlled conditions.

CDF curves were developed for each of the metals found in the river and marsh sediments. Although the CDF curves sometimes indicate a particular constituent to be widespread, the curves need to be read in context with the regional curves, which indicate normal expected ranges of a particular constituent.

Arsenic was detected throughout the system, mostly at levels slightly above the WD screening value of 8 mg/kg (Figures 4 and 5). CDF curves indicate that approximately 52 percent of the river sediments and 88 percent of the marsh sediments have concentrations above the WD screening value (Graphs 20 and 21). Station 5 in the marsh contained 48 mg/kg which put it slightly out of the regional curves developed for arsenic. All other values are well within their expected range (Graphs 1 and 2).

Cadmium was not detected in any of the river sediments. It was detected at only two marsh sampling stations: station 49 (2.1 mg/kg) and station 36 (1.5 mg/kg), (Figure 6). There are no regional curves for cadmium. The two stations, although higher than the WD screening value, are well below the ER-M of 9.6 mg/kg. Cadmium has a poor relationship to aluminum, and therefore was not plotted against the regional curves, nor were CDF curves developed.

Chromium is similar to arsenic in the system. It is ubiquitous throughout the system and at levels slightly higher than the WD screening value. CDF curves indicate that approximately 47 percent of the river sediments and 91 percent of the marsh sediments have concentrations higher than the WD screening value (Graphs 22 and 23). Concentrations are well below the 370 mg/kg ER-M level and within the normal regional range (Figures 7 and 8), (Graph 3 and 4).

Copper was detected at very low concentrations at all stations in the river and the marsh, except for marsh station 49, which had an elevated concentration of 130 mg/kg, (Figures 9

and 10). This concentration, (130 mg/kg), is almost half of the ER-M value of 270 mg/kg for copper. With the exception of marsh station 49, all data points are well within the regional curves. CDF curves indicate that all sediments in the river are below the WD screening value. Approximately 1 percent of the marsh sediments, which is represented by station 49 contains concentrations above the WD screening value (Graphs 24 and 25).

Lead concentrations were relatively low at all stations except station 49 in the river and station 49 in the marsh (Figures 11 and 12). CDF curves indicate that approximately 26 percent of the river sediments and 75 percent of the marsh sediments are greater than the WD screening value (Graphs 26 and 27). In actuality, concentration are only marginally greater than the screening value and all concentrations except for the above mentioned stations fall well within regional levels (Graphs 7 and 8). River station 49 and marsh station 49 both had concentrations of 120 mg/kg, which is more than double the ER-M value and well above the regional curves (Graphs 7 and 8)

The highest level of mercury in the river sediment (1.20 mg/kg) was at station 48 on Gibson Creek, (Figure 14) and the highest level of mercury in the marsh sediments (14.0 mg/kg) was at station 38 (Figure 15). Mercury concentrations at several stations were higher than the ER-M value of 0.71 mg/kg (Figures 14 and 15). Station 48 (1.20 mg/kg) in the river sediment and stations 32 (0.89 mg/kg), 38 (14.00 mg/kg) , and 49 (1.30 mg/kg) in the marsh sediment each contained concentrations higher than the ER-M value. Station 38 in the marsh, with a value of 14 mg/kg is nearly 20 times the ER-M value. CDF curves indicate that approximately 27 percent of the river sediments are above the WD screening value and approximately 3 percent of the river sediments are above the ER-M value (Graph 28). Approximately 4 percent of the marsh sediments contains concentrations of mercury greater than the ER-M value (Graph 29). Mercury has a poor relationship with aluminum, and therefore, was not plotted against the regional curves.

Nickel concentrations were low, (below the WD screening value), throughout the marsh and river, except for station 57 (44 mg/kg) in the marsh (Figures 16 and 17). This is indicated by the CDF curves as well, with approximately 2 percent of the marsh sediment concentrations above the WD screening value and none in the river sediments (Graphs 30 and 31). The concentration of nickel at station 57 is well above the screening value of 20.9 mg/kg, and close to the ER-M of 51.6 mg/kg. All concentrations except for those of station 57 fall within the regional curves for nickel (Graphs 9 and 10).

Zinc concentrations were fairly low in both the marsh and river sediments with the exception of station 49 (530 mg/kg) in the marsh, which is well above the ER-M of 410 mg/kg (Figures 18 and 19). CDF curves indicate approximately 12 percent of the river sediments and approximately 35 percent of the marsh sediments greater than the WD screening value (Graphs 32 and 33). Station 49 in the river sediments had a value of 170 mg/kg, which is well below the ER-M but falls above the regional curve (Graphs 11 and 12). This indicates levels above normal background.

#### 4.2.2 Sediment PCB's/Pesticides

Araclor 1268 was the only compound detected in the PCB/pesticide database for both the river and marsh sediments (Appendix B-2 and C-2). Stations 8, 11, 12, 32, 44, 48, 68, 69 and 71 in the river sediments and stations 16, 18, 21, 23, 27, 32, 38, 40, and 74 in the marsh sediments each contained concentrations higher than 500 ug/kg. Stations 48 (1400 ug/kg) and 69 (5200 ug/kg) in the river sediments and station 38 (4200 ug/kg) in the marsh contained the highest concentrations of araclor 1268 (Figures 38 and 39). CDF curves indicate concentrations are below 100 ug/kg in approximately 80 percent of the study area (Graphs 34 and 35).

At station 49 toxaphene was listed as below detection limits, but at a very high sample detection limit of 70,000 ug/kg. This indicates that there may be high concentrations of some compound or group of compounds at this station of which toxaphene may be one of the constituents. Otherwise there were no other PCB or pesticide compounds detected.

#### 4.2.3 Sediment Extractable Organic Compounds

Several non-toxic fatty acids normally found in fish tissue and other organic matter were detected. These included decanoic acid, hexadecanoic acid, hexadecenoic acid, pentadecanoic acid, octadecanoic acid and tetradecanoic acid. These acids, and hexadecanoic acid in particular, accounted for approximately 50 percent of the values in the river sediments and approximately 90 percent of the values in the marsh sediments. With the exception of fatty acids, the vast majority of analyses at most stations yielded below detection limit values (Appendix B-3, C-3). Eighteen stations in the river sediments contained concentrations of organic compounds above detectable levels. Of the eighteen stations, all but two stations contained less than five compounds. Station 49 contained fourteen compounds and station 77 contained eight compounds. Station 77 contained the only quantifiable value (pyrene 2700 ug/kg). All of the other values in the data set were estimated values. Pyrene has a NOEL value of 290 ug/kg and an ER-M value of 2600 ug/kg. Both station 49 and 77 contain values for benzo (A) anthracene, benzo (A) pyrene, chrysene and fluoranthene which are well above the NOEL value, but below the ER-M value, thus indicating a moderate level of toxicity at these stations. Only nine stations in the marsh sediments had detectable concentrations for compounds other than the fatty acids listed above. All concentrations are estimated values and most are low values. Station 4 contained the highest value in the data set (kaurenoic Acid 200,000 ug/kg estimated value). Following is a list of extractable organic compounds, (in addition to the fatty acids listed above), found in the river and marsh sediments.

COMPOUND

RIVER STATION

MARSH STATION

(3-and/or 4-)Methylphenol		BM066
Benzo (A) Anthracene	BR049, BR077	
Benzo (b and/or k) Fluoranthene	BR015, BR036, BR049, BR077	BM060
Benzo (GHI) Perylene	BR049, BR077	
Benzo (A) Pyrene	BR049, BR077	
Chloraniline	BR049	
Chrysene	BR049, BR077	
Fluoranthene	BR015, BR048, BR049, BR077	BM060
Indeno (1,2,3-cd) Pyrene	BR049, BR077	
Phenanthrene	BR015	
Phenol		BM066
(3- and/or 4-) Methylphenol		BM066
Pyrene	BR015, BR049, BR069, BR077	BM060
Tetramethylphenanthrene	BR049	
Dimethylbinaphthalene		BM008
Dimethyldinaphthalene		BM015
Dimethylheptanone		BM011, BM012, BM014
Methaqualone		BM031, BM033
Cyclododecanol		BM023, BM033, BM040
Benzeneacetic Acid		BM066
Kaurenoic Acid		BM004

#### 4.2.4 Sediment Purgeable Organic Compounds

Acetone was detected at stations 13 (740 ug/kg), 52 (690 ug/kg), and 56 (1500 ug/kg) in the river sediments. Station 57 in the river sediments had an estimated concentration of 200 ug/kg of Thiobismethane. Thiobismethane was the only purgeable organic compound detected in the marsh sediments. It was detected at seventeen of the marsh station locations. Station 54 contained 20,000 ug/kg. Concentrations at all other stations were 1000 ug/kg or less (Appendix B-4 and C-4).

#### 4.3 Fish Sampling Results

The fish sampling effort was limited to the mummichog, (*F. heteroclitis*), since this species is likely to spend its life within a limited range. The fish sampling stations, a randomly selected subset of the river sampling stations (Figure 1) are shown in Figure 3. Its body concentrations of accumulatable anthropogenic compounds is more likely to reflect concentrations found in near-by waters and sediments than would the concentrations of compounds found in pelagic food-fish species that seasonally travel through estuarine waters. For this reason and since the mummichog forms a forage base for piscivorous fish, birds and mammals, it is a useful selection for this study.

Fish were analyzed as whole body. A consequence of analyzing whole body rather than fillet samples is the inclusion of mineralized bone tissue, which, due to its high concentration of calcium necessarily raises detection limits obtainable for other inorganic materials. Some sample detection limits that were obtained here would have been lower had samples not included bone.

#### 4.3.1 Fish Metals

Copper (Figure 22), strontium, titanium, zinc (Figure 26), aluminum and manganese were detected in *Fundulus* samples from all or nearly all stations (Appendix D-1; Figure 3). Barium was detected in about half of the stations sampled. There are no criteria and little guidance on the effect of body burdens of these metals to fish. Vanadium was detected in *Fundulus* for station 70 only. Nickel (Figure 25) and chromium (Figure 21), were detected in fish only from station 55.

Chromium was present at only one station, (55), at a concentration of 1.7 mg/kg (Figure 21). Individual tissues of most species of fin fishes normally contain between 0.1 and 0.6 mg Cr/kg fresh weight (Hall et al. 1978). The US. Fish and Wildlife service has proposed a criterion of below 0.2 mg Cr/kg in animal tissues for the protection of selected resources (Eisler, 1986). Therefore, chromium may be present at an undesirable concentration in fish at station 55.

Lead was detected in fish only at station 48 (Figure 21) at a concentration of 0.19 mg/kg. Currently there is no protective criteria for concentrations of lead in whole fish.

Arsenic was detected in fish from stations 41, 48, 51 and 54 at concentrations that range from 1.0 to 2.0 mg/kg (Figure 20).

Mercury was detected in fish collected from all stations along the Turtle River and its tributaries as well as along the Frederica River (Figure 24). Mercury was not detected in fish from any station in the creeks immediately east of Brunswick or from stations south of the Brunswick River. Concentrations of mercury in fish ranged from 0.023 to 0.083 mg/kg. In general, mercury concentrations in fish are usually less than 1.0 mg/kg fresh tissue weight in organisms not directly exposed to anthropogenic sources (Eisler 1987).

#### 4.3.2 Fish PCB's/Pesticides

Pesticides and PCBs were not detected in whole-body samples of F. heteroclitus except that toxaphene concentrations of 19 and 27 mg/kg were estimated in duplicate samples taken at the Terry Creek station (Station 49; Appendix D-2). Although there is limited information available linking fish tissue levels of toxaphene with biological effect, a Lake Michigan study found whole body concentrations of 5 to 10 mg/kg of toxaphene to be harmful to sensitive species of fresh water teleosts (Schmidt et al. 1983). In laboratory studies, Brook Trout Salvelinus fontinalis, tissue residues exceeding 0.4 mg/kg of toxaphene were associated with reductions in growth, abnormal bone development and reduced fecundity (Mayer and Mehrle, 1977). In another study, Brown Trout eggs containing 0.9 mg/kg of toxaphene had drastically reduced survival when compared with controls (Cohen et al. 1982). Therefore, the levels of toxaphene found in Fundulus at station 49 should be considered harmful.

#### 4.3.3 Fish Extractable Organic Compounds

The only extractable organic compounds that were identified in fish analyses were seven non-toxic fatty acids which are natural components of biological systems.

#### 4.4 Dioxins/furans in River Sediments

The most toxic component of the dioxin series, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is considered the most potent known animal carcinogen. Fish are among the most sensitive animals to TCDD and related compounds (US-EPA, 1993b). TCDD was detected in sediments sampled in this study area (Figure 24) at concentrations ranging from 1.1 to 5.0 ng/kg. There is a low risk to fish, mammalian wildlife and avian wildlife when sediment concentrations are 60, 2.5, and 21 ng/kg of TCDD respectively, and a high risk to these animal groups when sediment concentrations are 100, 25, and 210 ng/kg of TCDD respectively (US-EPA, 1993b).

Toxic Equivalent Values (TEQs) are calculated including all dioxin isomers identified in a sample, weighted to reflect their relative toxicities. TEQs for stations sampled during this study range from zero to an estimated value of 18 (Figure 40).

## 5.0 FIGURES

- FIGURE 1: River Sampling Stations
- FIGURE 2: Marsh Sampling Stations
- FIGURE 3: Fish Sampling Stations
- FIGURE 4: Arsenic in River Sediments
- FIGURE 5: Arsenic in Marsh Sediments
- FIGURE 6: Cadmium in Marsh Sediments
- FIGURE 7: Chromium in River Sediments
- FIGURE 8: Chromium in Marsh Sediments
- FIGURE 9: Copper in River Sediments
- FIGURE 10: Copper in Marsh Sediments
- FIGURE 11: Lead in River Sediments
- FIGURE 12: Lead in Marsh Sediments
- FIGURE 13: Low Level Mercury in Water
- FIGURE 14: Mercury in River Sediments
- FIGURE 15: Mercury in Marsh Sediments
- FIGURE 16: Nickel in River Sediments
- FIGURE 17: Nickel in Marsh Sediments
- FIGURE 18: Zinc in River Sediments
- FIGURE 19: Zinc in Marsh Sediments
- FIGURE 20: Arsenic in Fish
- FIGURE 21: Chromium in Fish
- FIGURE 22: Copper in Fish
- FIGURE 23: Lead in Fish
- FIGURE 24: Mercury in Fish
- FIGURE 25: Nickel in Fish
- FIGURE 26: Zinc in Fish
- FIGURE 27: 2,3,7,8 Tetrachlorodibenzodioxin (TCDD) in River Sediments
- FIGURE 28: Tetrachlorodibenzodioxin (Total) in River Sediments
- FIGURE 29: Pentachlorodibenzodioxin (Total) in River Sediments
- FIGURE 30: Hexachlorodibenzodioxin (Total) in River Sediments
- FIGURE 31: Heptachlorodibenzodioxin (Total) in River Sediments
- FIGURE 32: Octachlorodibenzodioxin (Total) in River Sediments
- FIGURE 33: Terachlorodibenzofuran (Total) in River Sediments
- FIGURE 34: Pentachlorodibenzofuran (Total) in River Sediments
- FIGURE 35: Hexachlorodibenzofuran (Total) in River Sediments
- FIGURE 36: Heptachlorodibenzofuran (Total) in River Sediments
- FIGURE 37: Octachlorodibenzofuran (Total) in River Sediments
- FIGURE 38: Aroclor 1268 in River Sediments
- FIGURE 39: Aroclor 1268 in Marsh Sediments
- FIGURE 40: Dioxin Toxic Equivalency Values (TEQ) in River Sediments

# BRUNSWICK COMMUNITY STUDY 12/95

## RIVER SAMPLING STATIONS

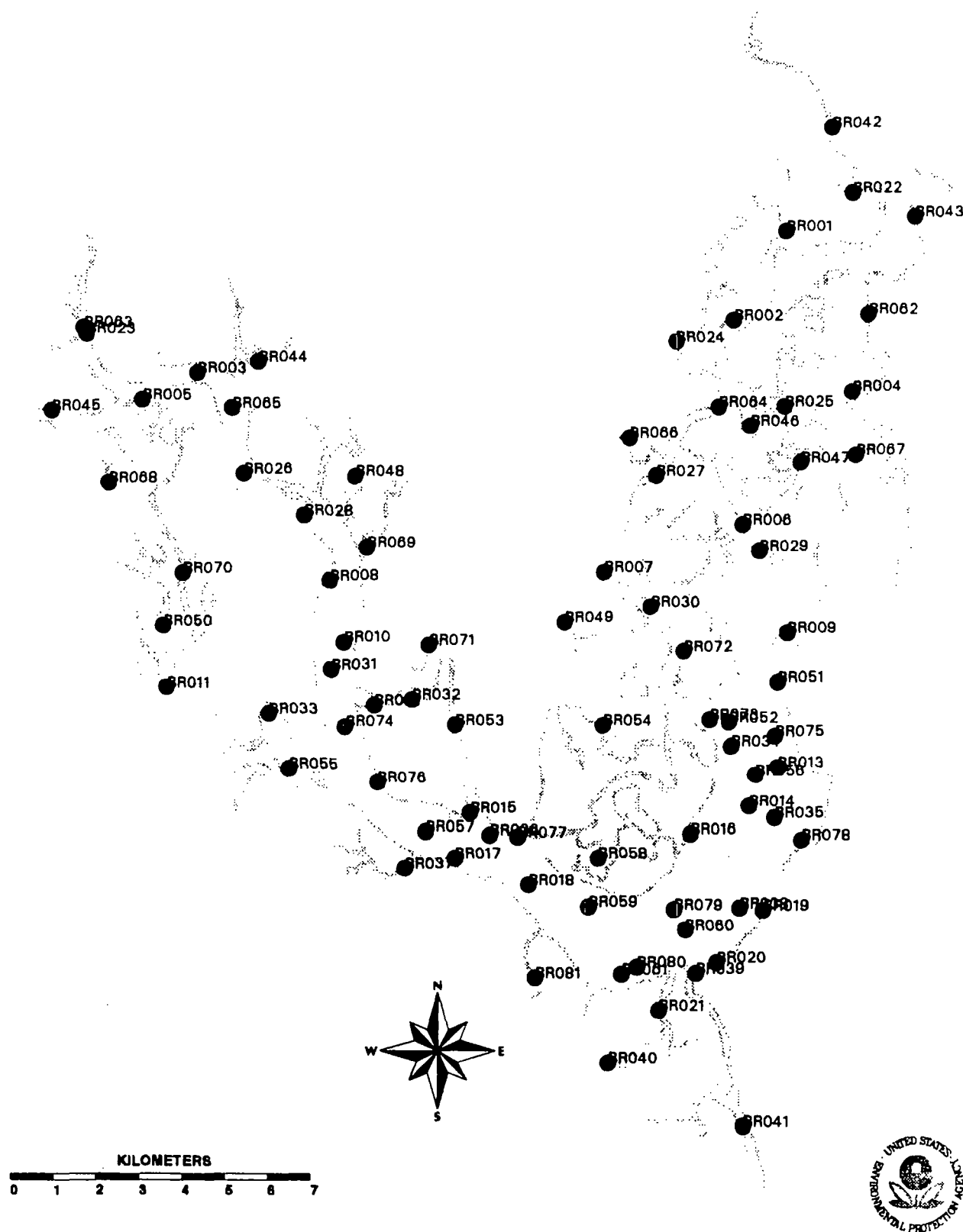
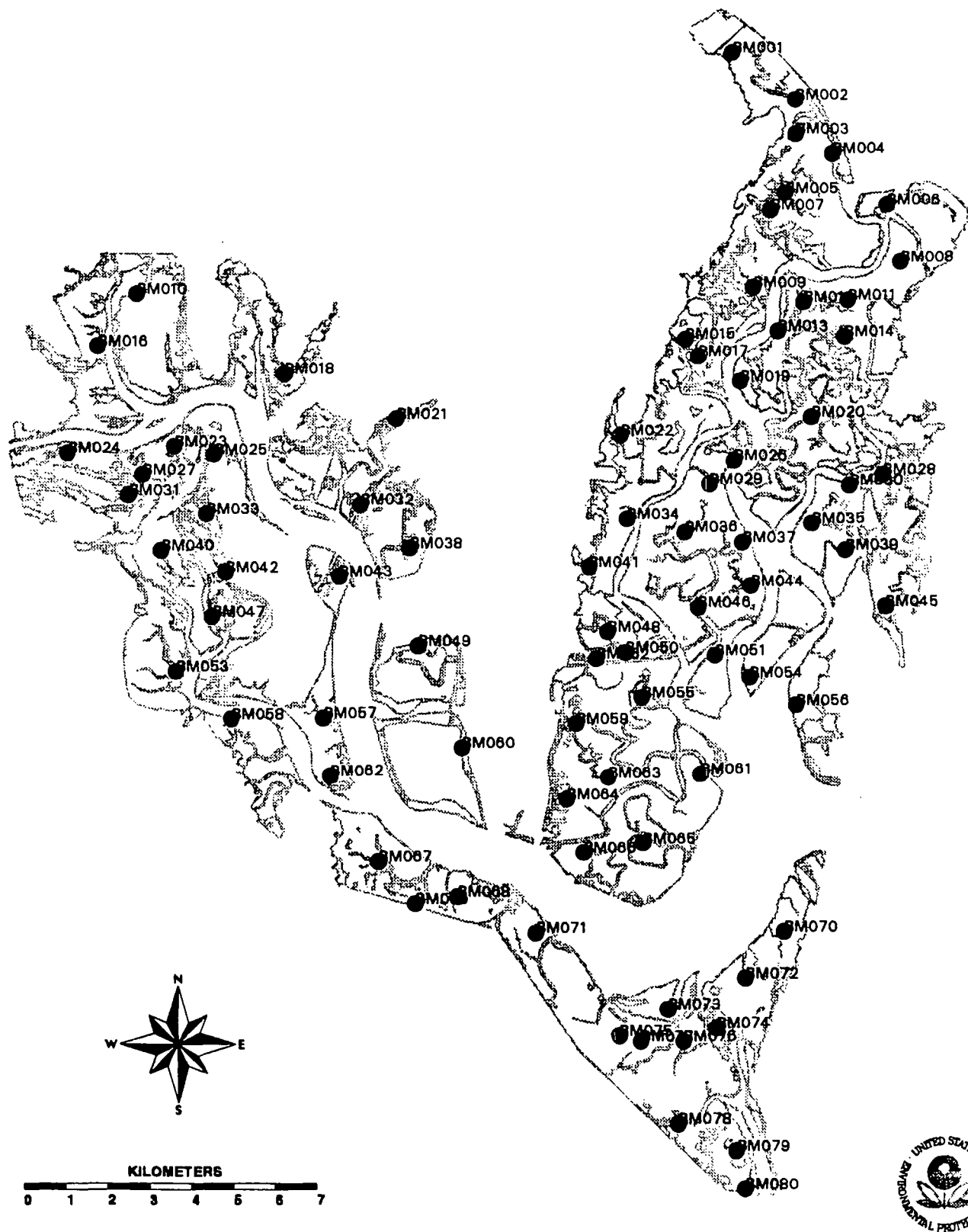


FIGURE 1



# BRUNSWICK COMMUNITY STUDY 12/95

## MARSH SAMPLING STATIONS



**FIGURE 2**

# BRUNSWICK COMMUNITY STUDY 12/95

## FISH SAMPLING STATIONS

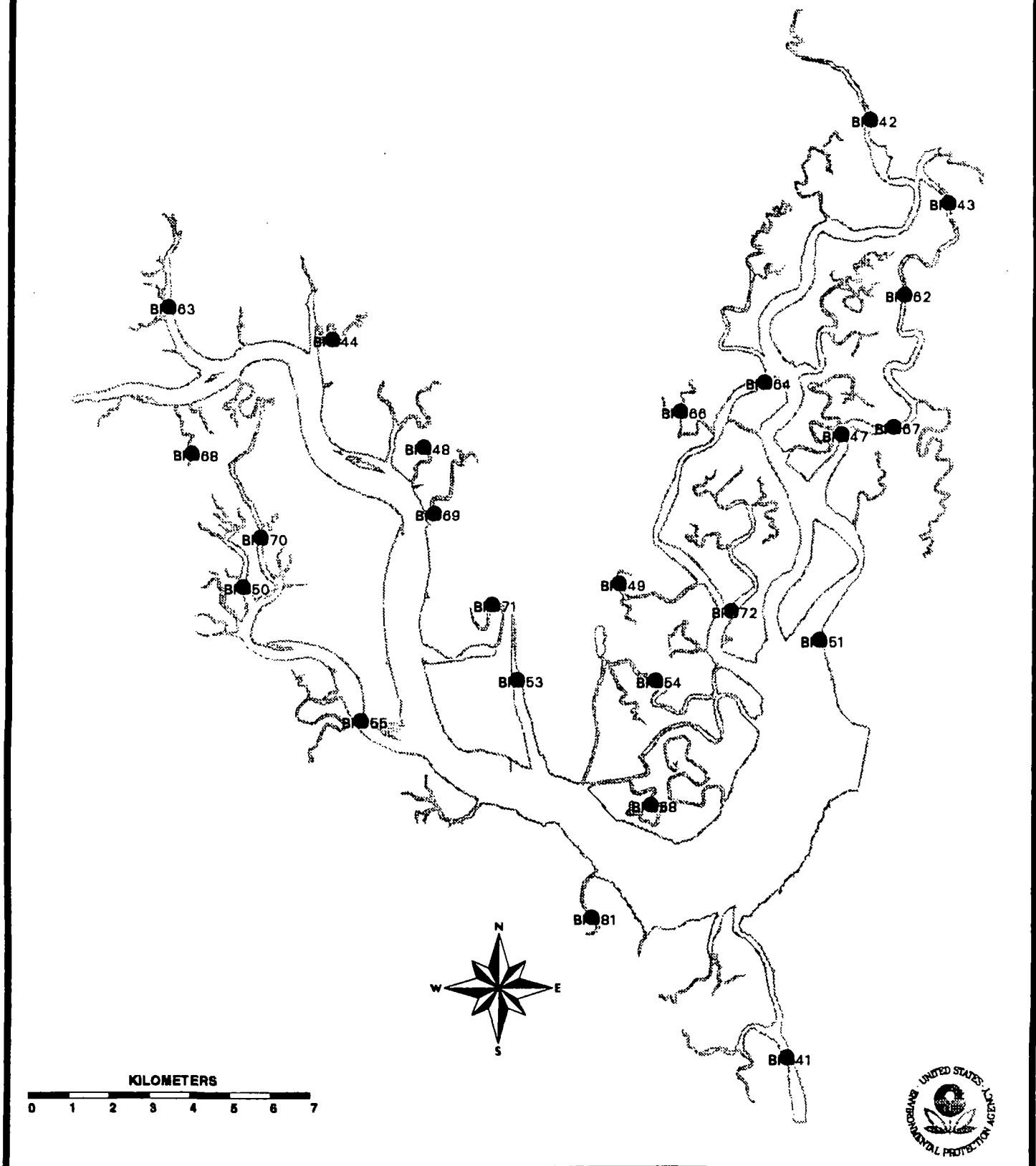
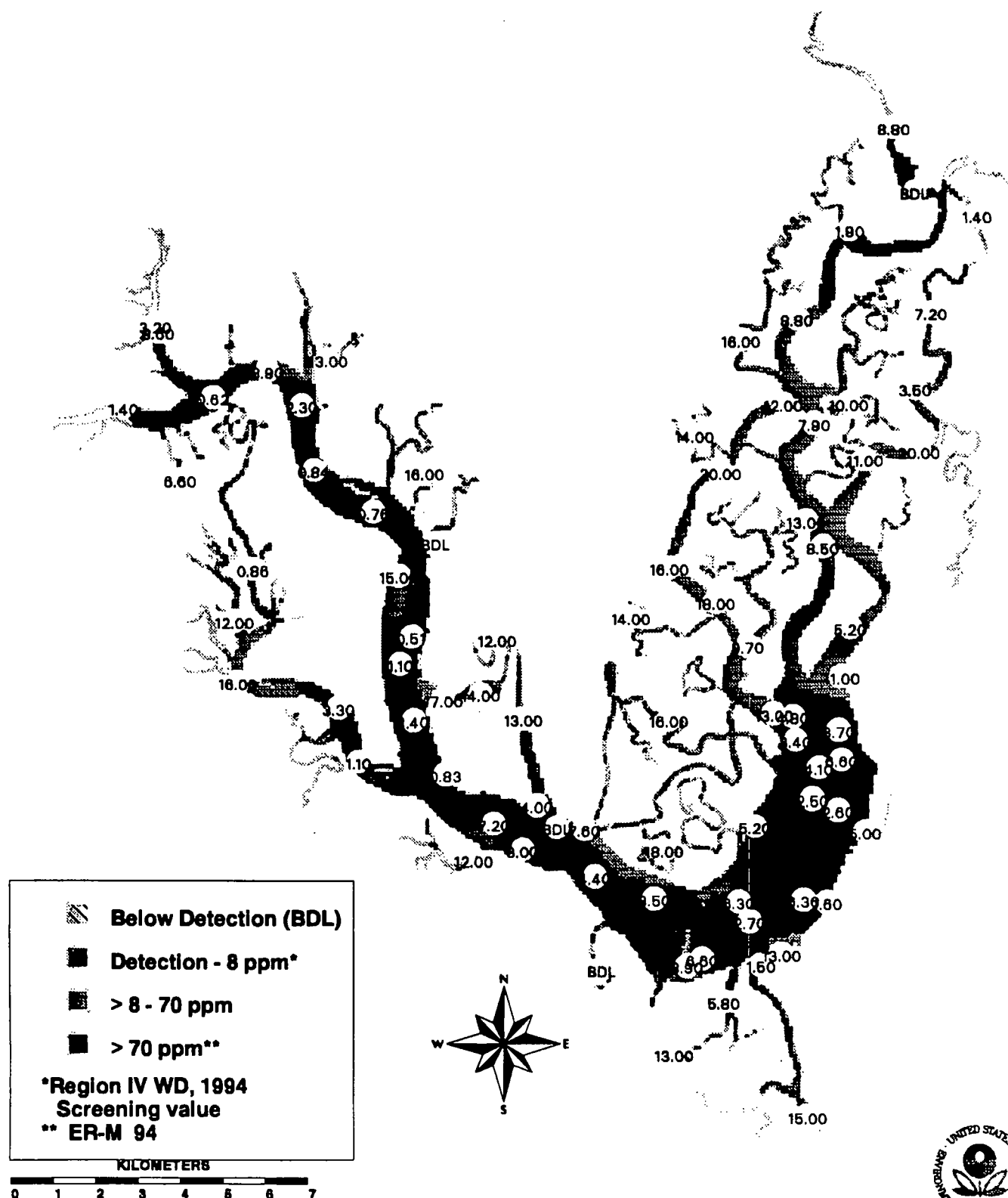


FIGURE 3

# BRUNSWICK COMMUNITY STUDY 12/95

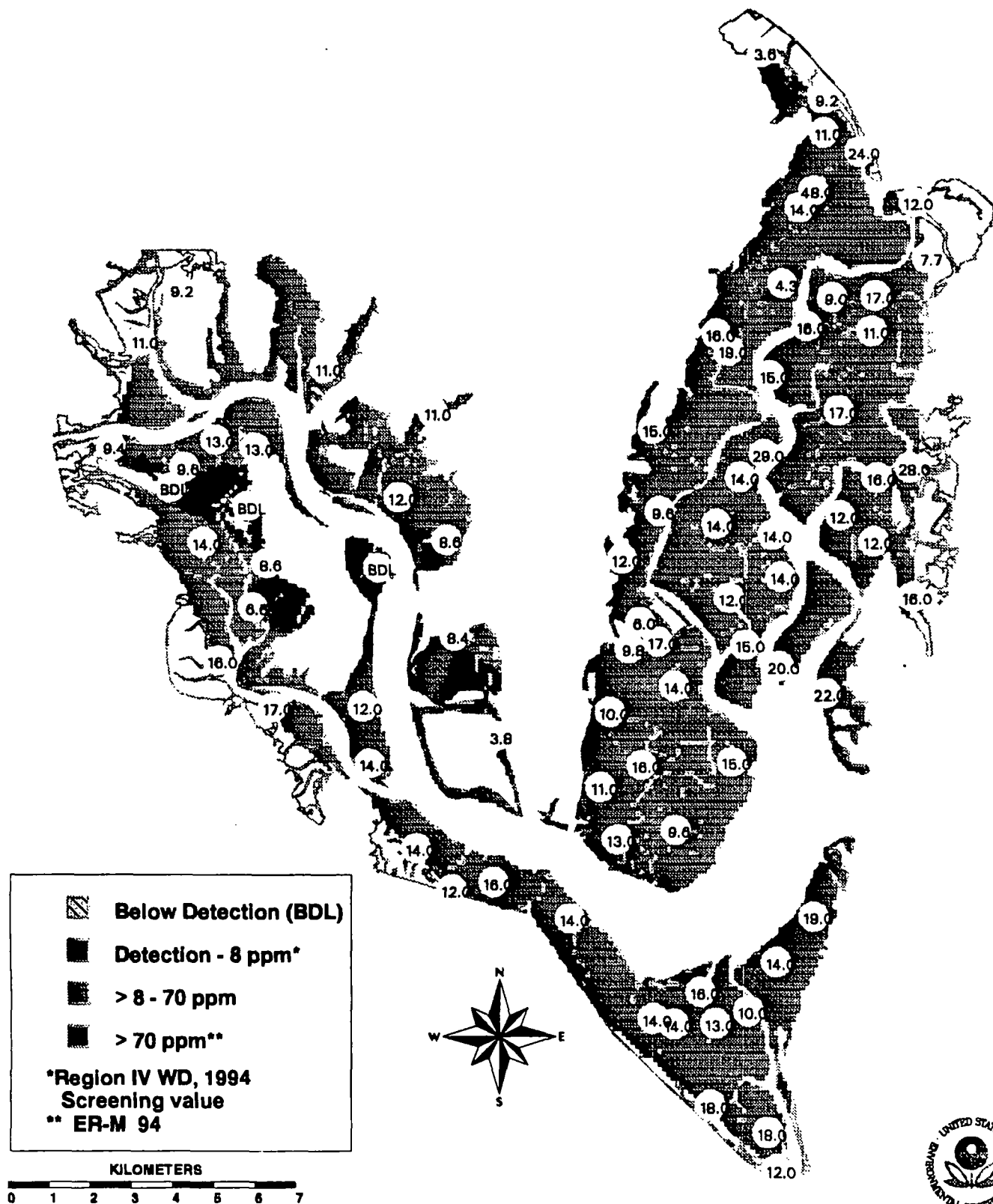
## ARSENIC IN RIVER SEDIMENTS



## FIGURE 4

# BRUNSWICK COMMUNITY STUDY 12/95

## ARSENIC IN MARSH SEDIMENTS



# BRUNSWICK COMMUNITY STUDY 12/95

## CADMIUM IN MARSH SEDIMENTS

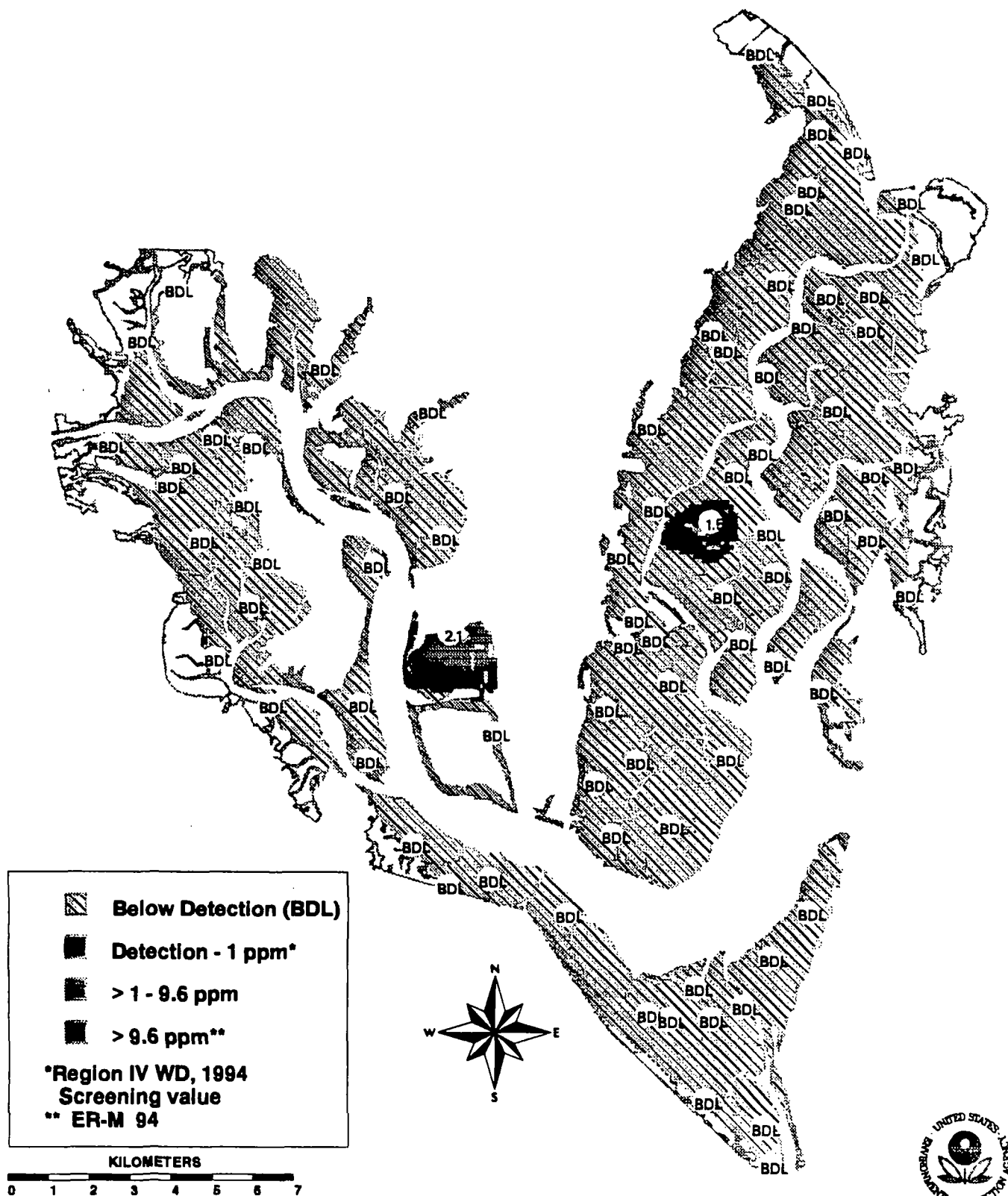
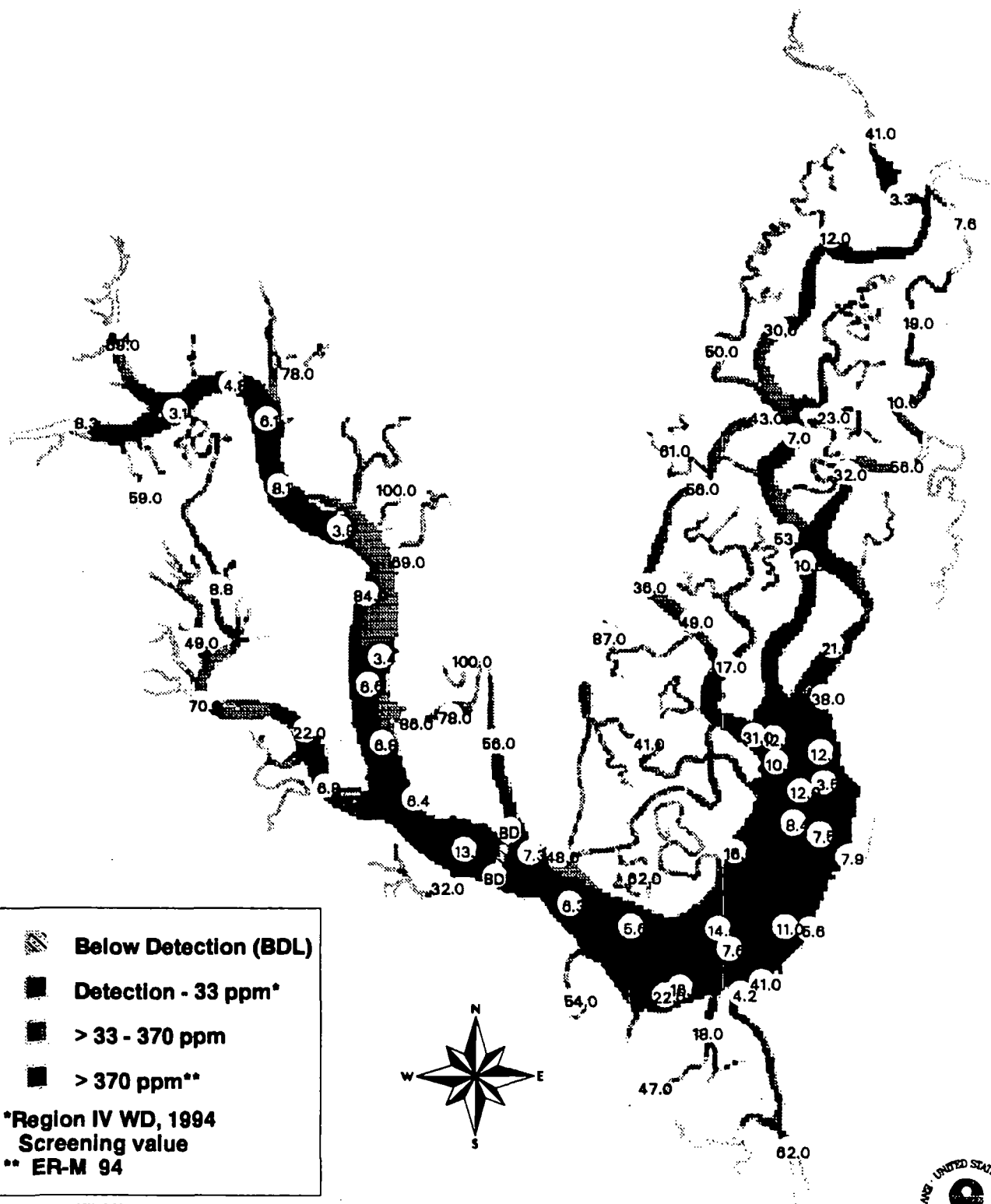


FIGURE 6

# BRUNSWICK COMMUNITY STUDY 12/95

## CHROMIUM IN RIVER SEDIMENTS



**FIGURE 7**

# BRUNSWICK COMMUNITY STUDY 12/95

## CHROMIUM IN MARSH SEDIMENTS

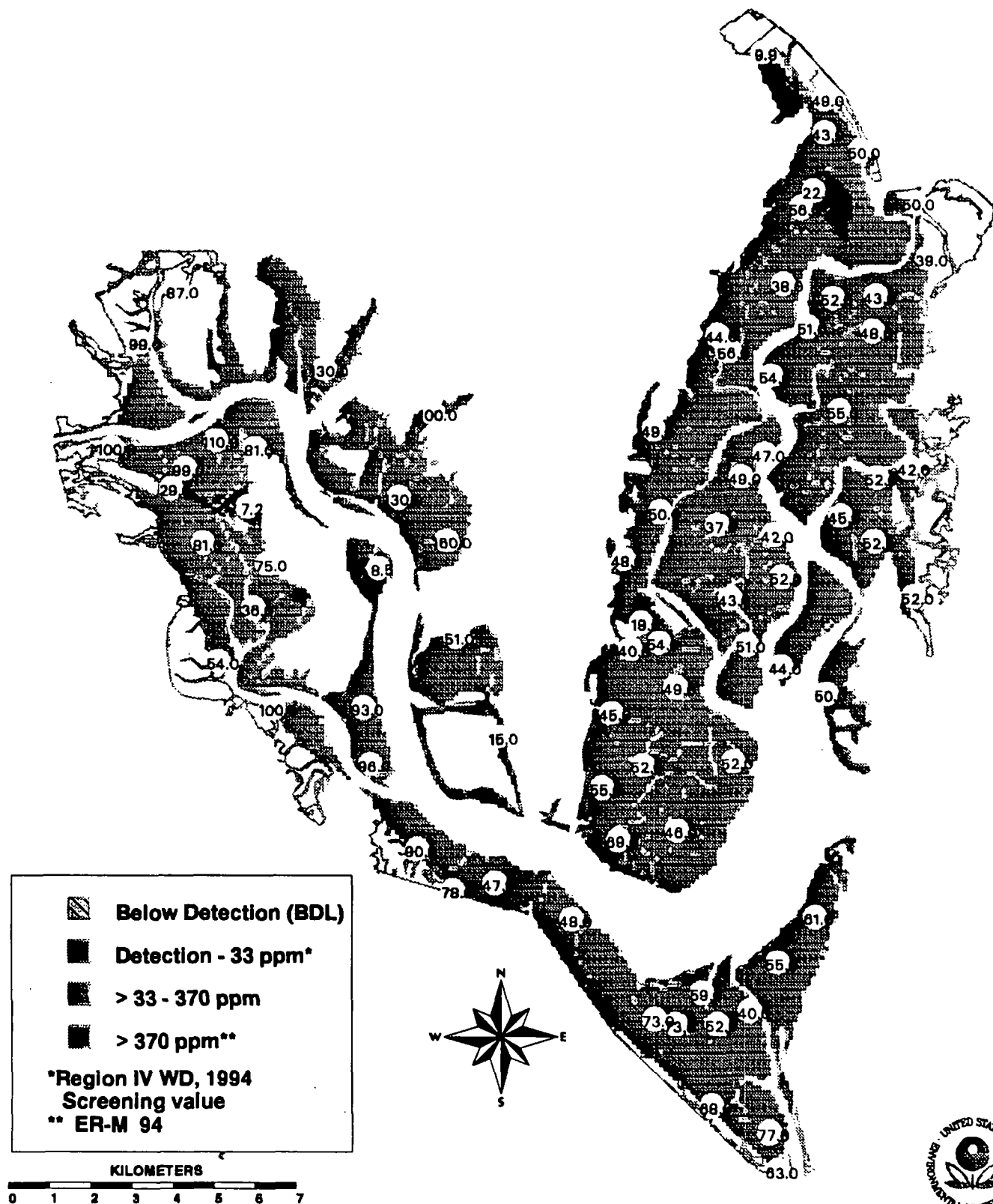


FIGURE 8

**KILOMETERS**



0 1 2 3 4 5 6 7



## FIGURE 9



# BRUNSWICK COMMUNITY STUDY 12/95

## COPPER IN MARSH SEDIMENTS

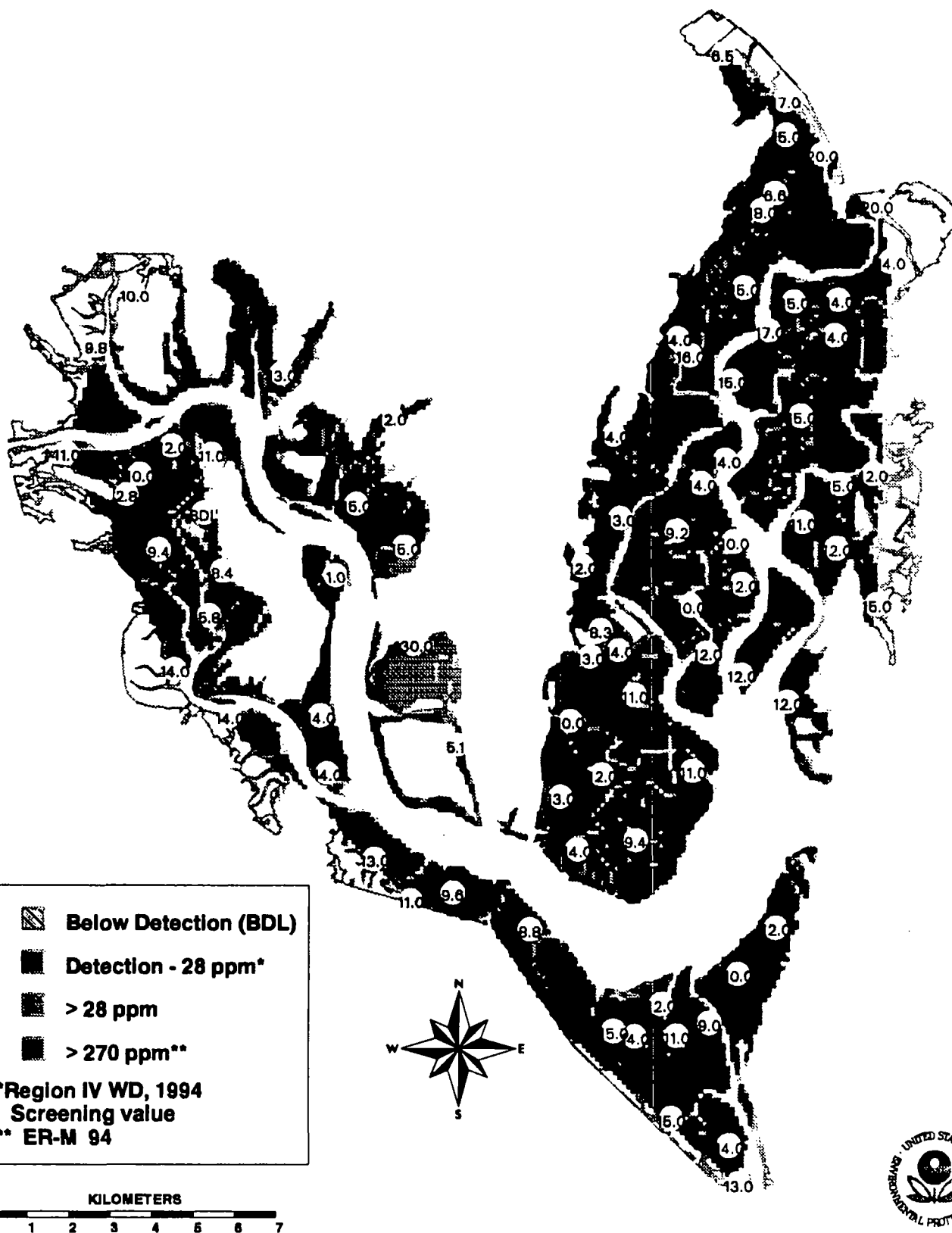
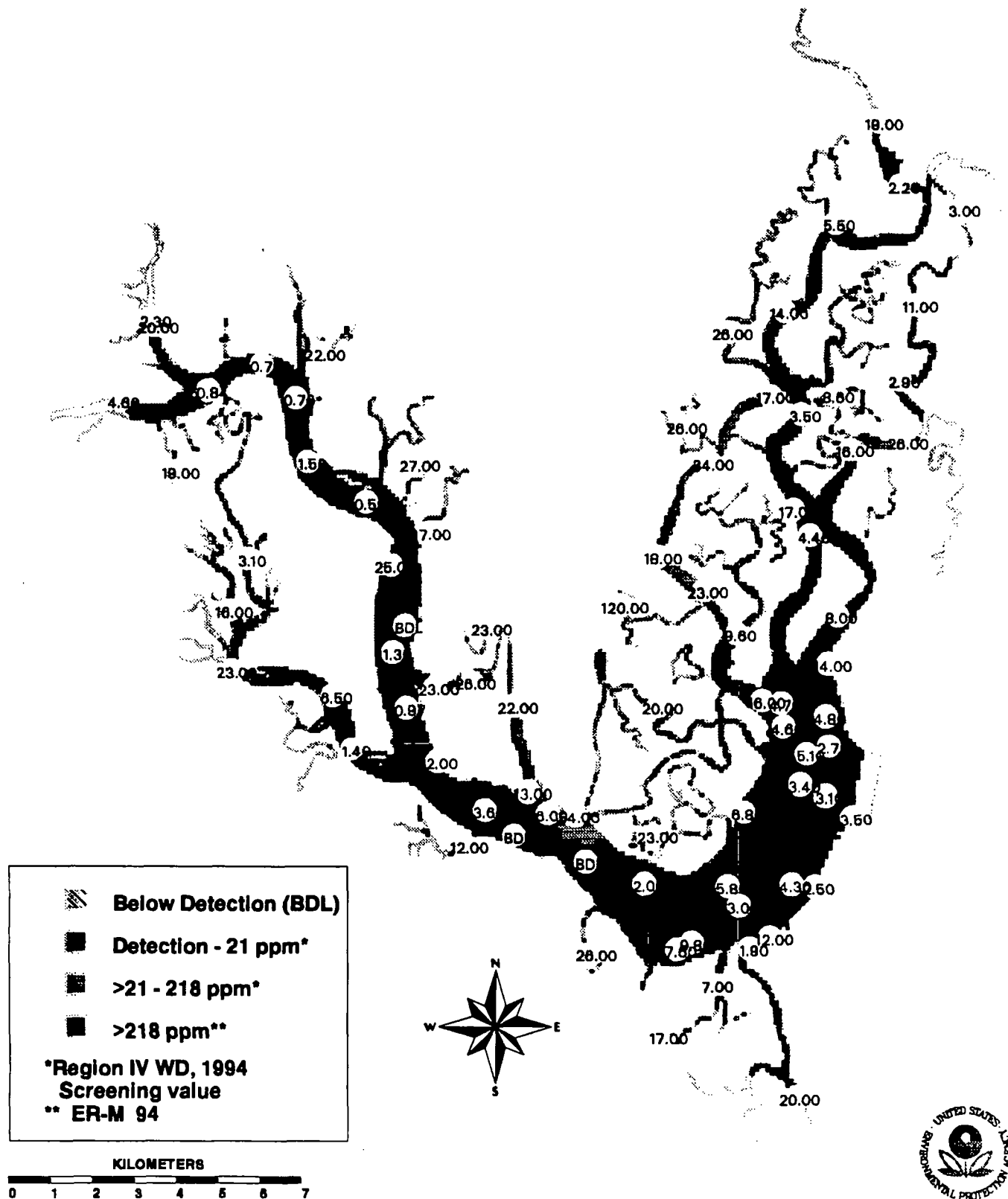


FIGURE 10

# BRUNSWICK COMMUNITY STUDY 12/95

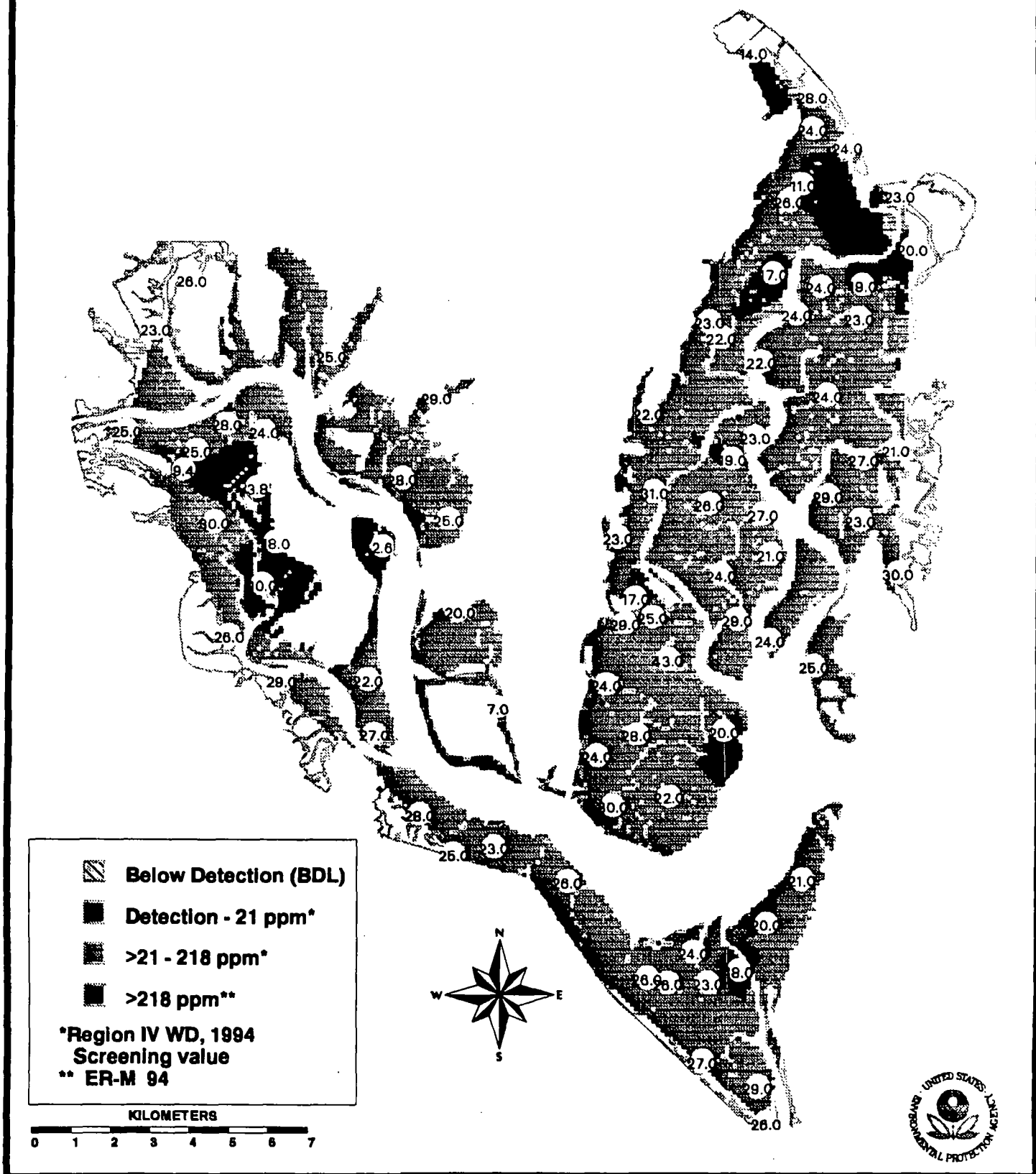
## LEAD IN RIVER SEDIMENTS



### FIGURE 11

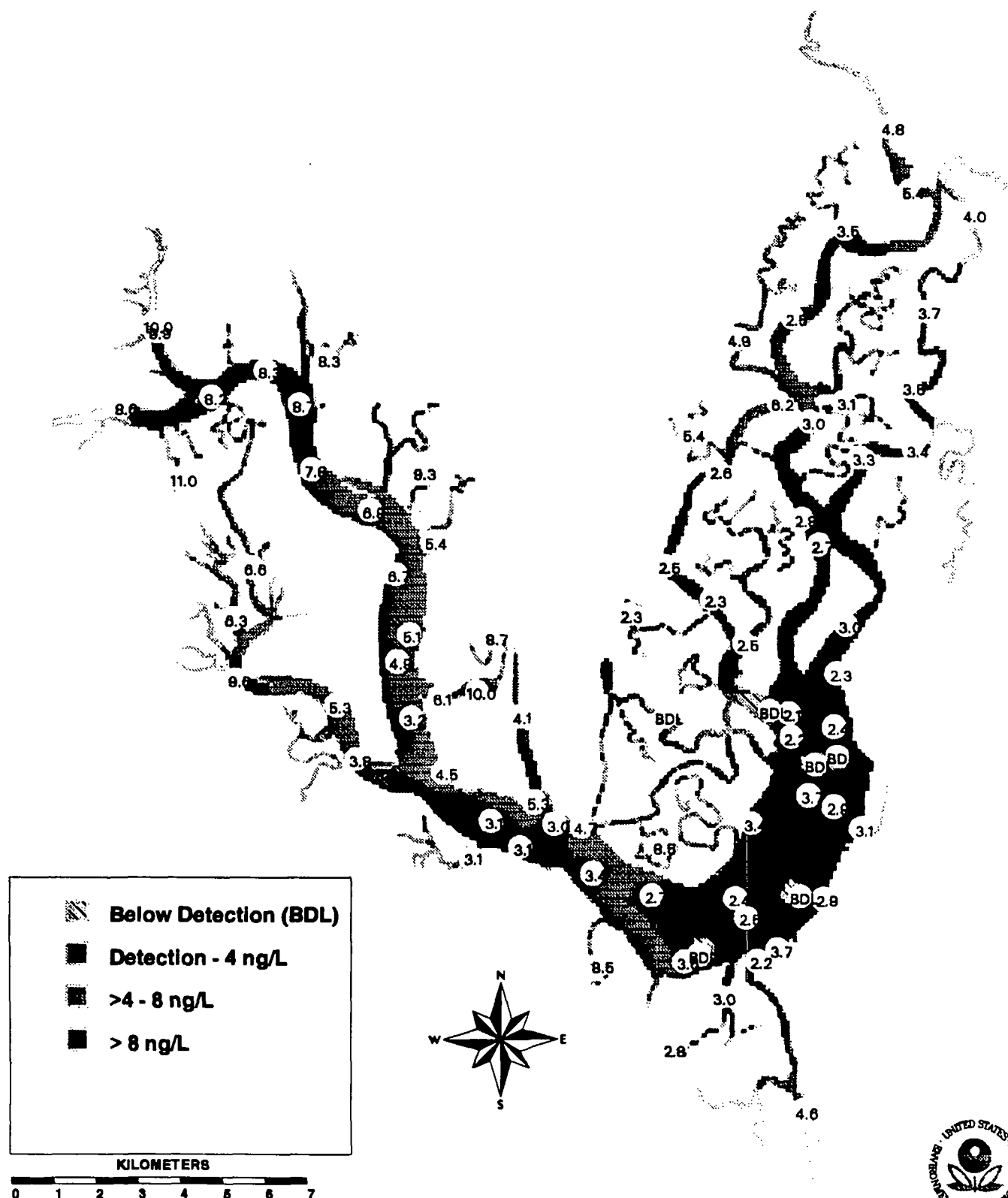
# BRUNSWICK COMMUNITY STUDY 12/95

## LEAD IN MARSH SEDIMENTS



## FIGURE 12

**BRUNSWICK COMMUNITY STUDY 12/95**  
**LOW LEVEL MERCURY IN WATER**



### FIGURE 13

[illegible]

**KILOMETERS**

0 1 2 3 4 5 6 7



### FIGURE 14

**Legend:**

- Below Detection (BDL)
- Detection - 0.1 ppm\*
- > 0.1 - 0.71 ppm
- > 0.71 ppm\*\*

**Region IV WD, 1994**  
**Screening value**  
**\*\* ER-M 94**

**Kilometers**

0 10

**North Arrow**

N  
W E  
S



### FIGURE 15

# BRUNSWICK COMMUNITY STUDY 12/95

## NICKEL IN RIVER SEDIMENTS

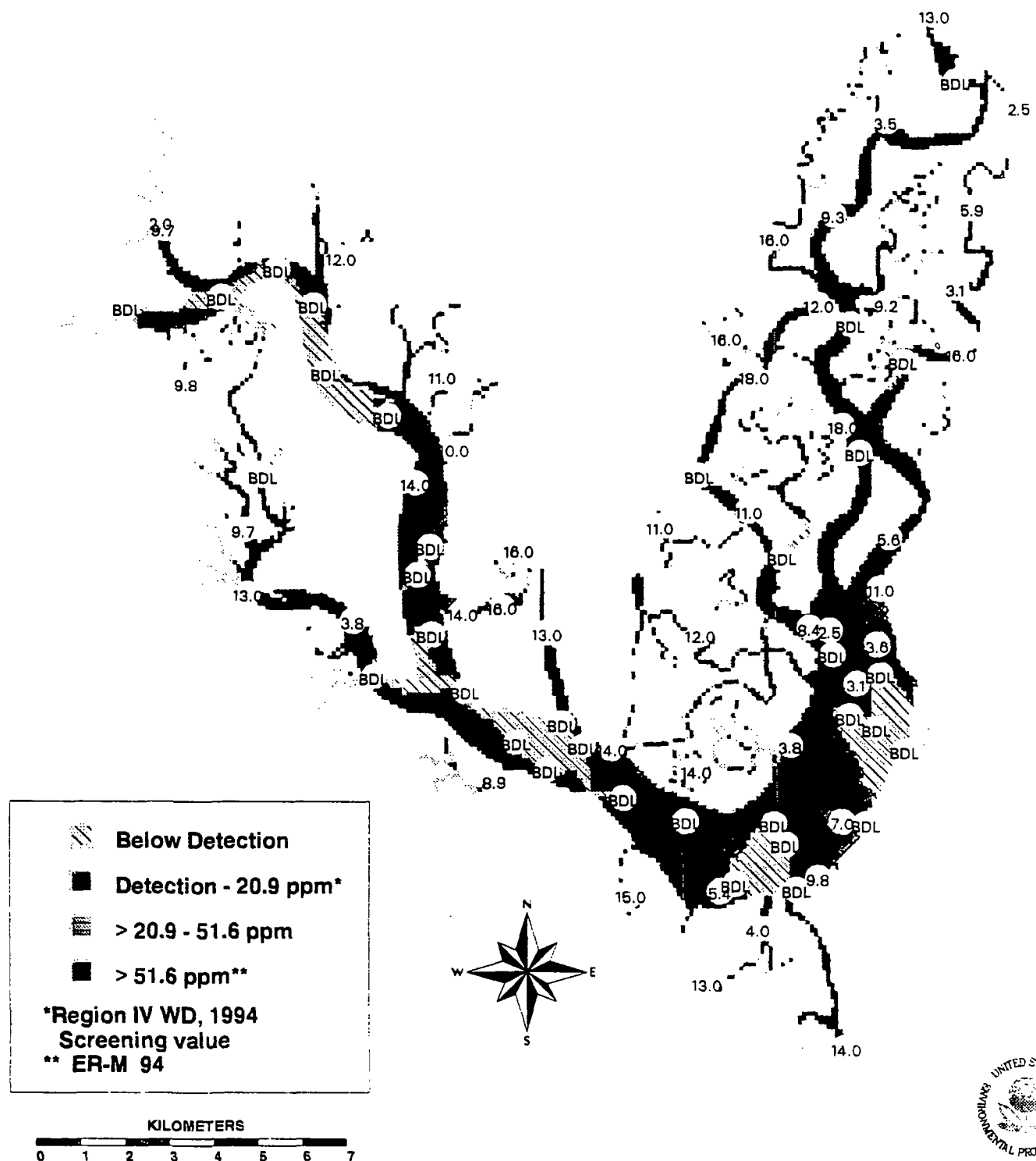


FIGURE 16

**Legend:**

- Below Detection
- Detection - 20.9 ppm\*
- > 20.9 - 51.6 ppm
- > 51.6 ppm\*\*

**Region IV WD, 1994**  
Screening value

**\*\* ER-M 94**

**KILOMETERS**

**Compass Rose:** N, S, E, W

### FIGURE 17



# BRUNSWICK COMMUNITY STUDY 12/95

## ZINC IN RIVER SEDIMENTS

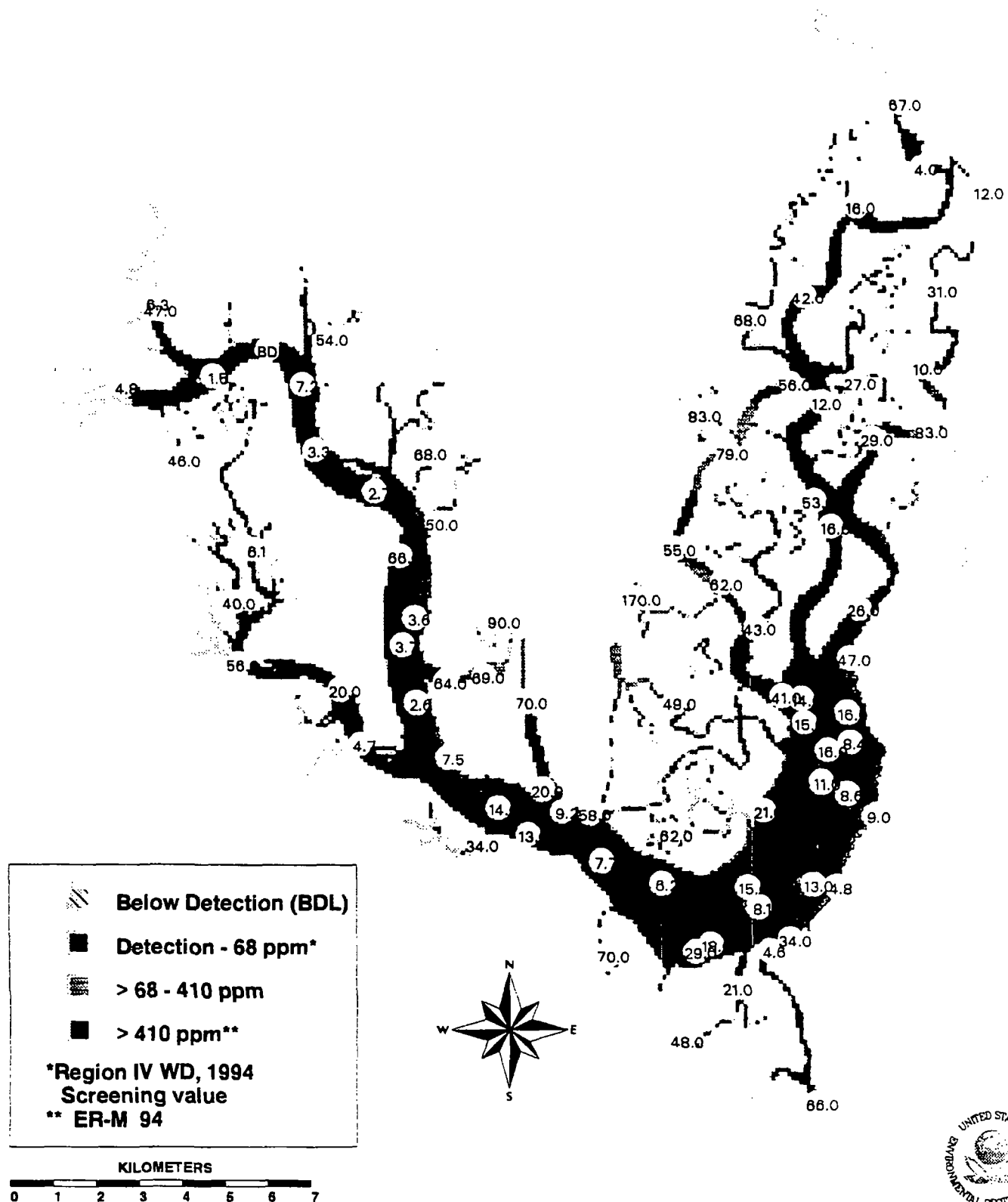
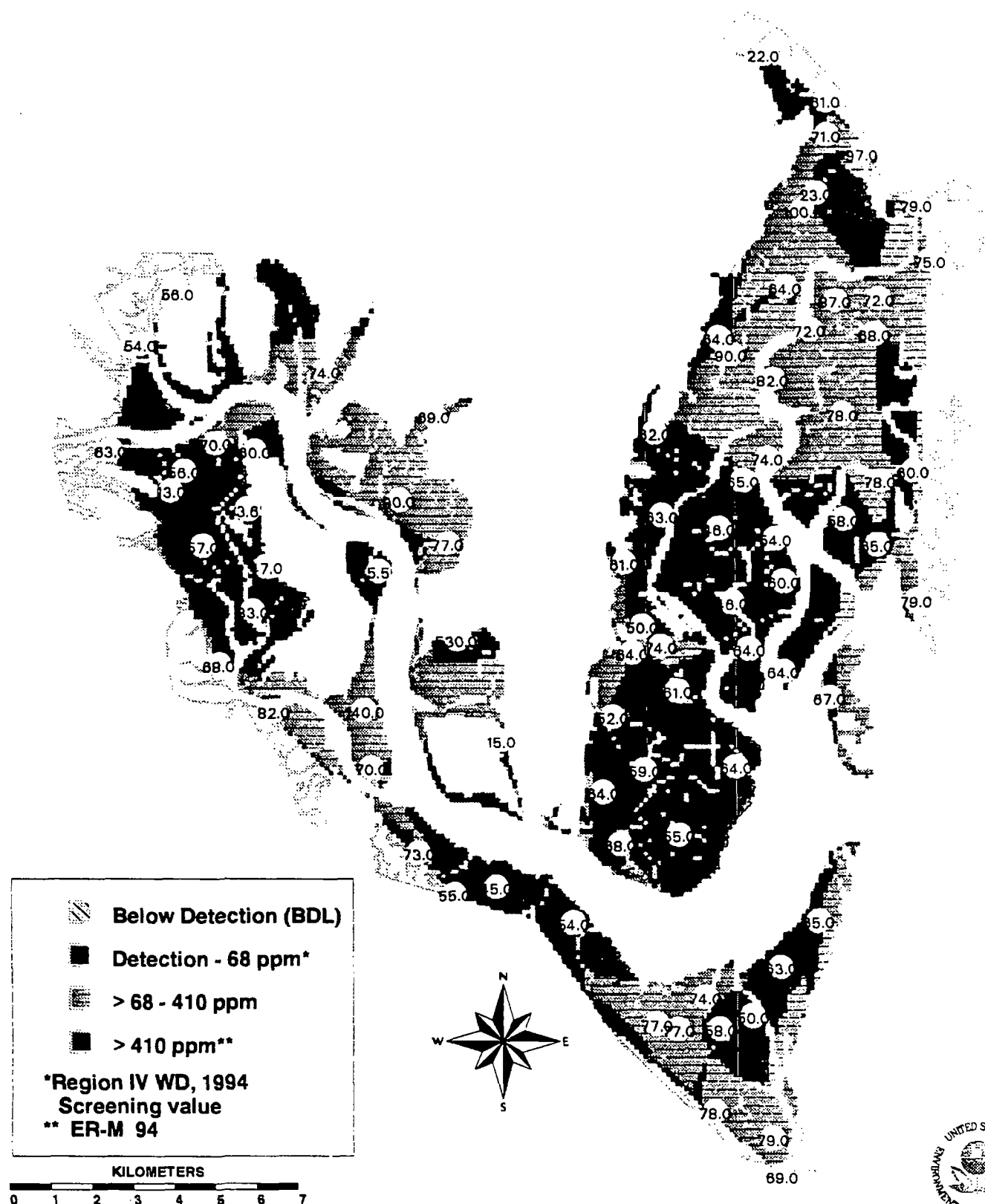


FIGURE 18

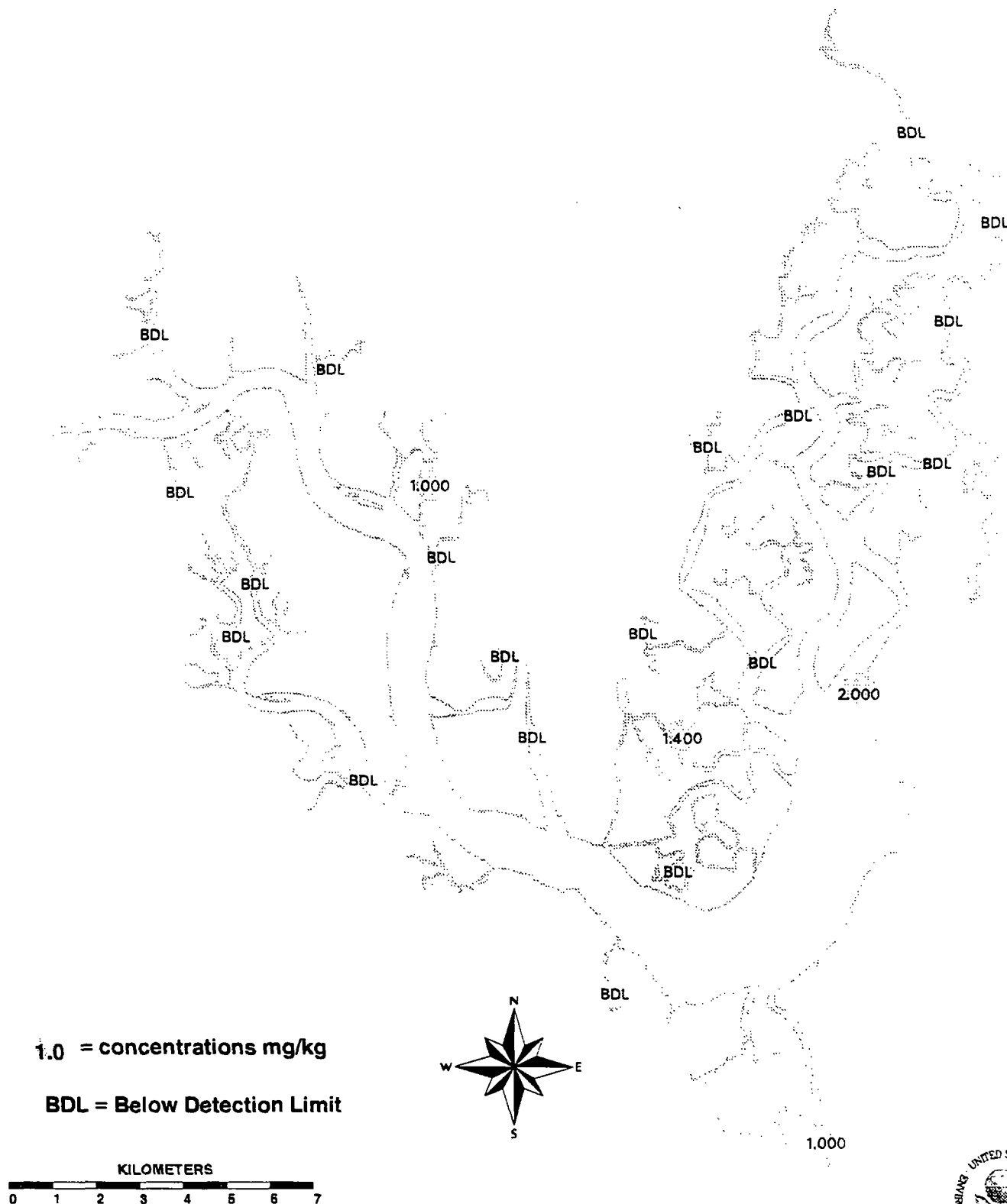
# BRUNSWICK COMMUNITY STUDY 12/95

## ZINC IN MARSH SEDIMENTS



### FIGURE 19

## ARSENIC IN FISH



### FIGURE 20

# BRUNSWICK COMMUNITY STUDY 12/95

## CHROMIUM IN FISH

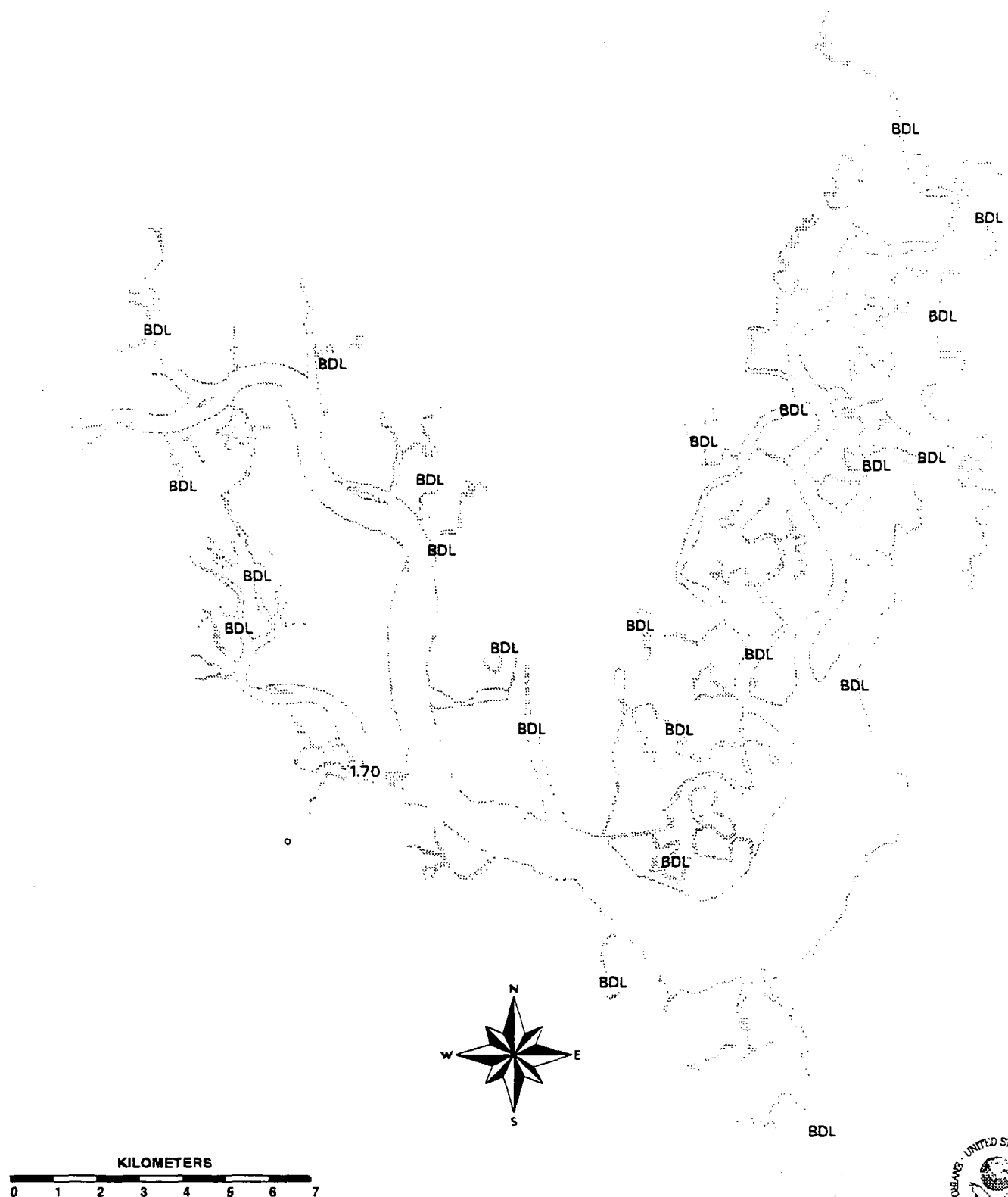


FIGURE 21

# BRUNSWICK COMMUNITY STUDY 12/95

## COPPER IN FISH

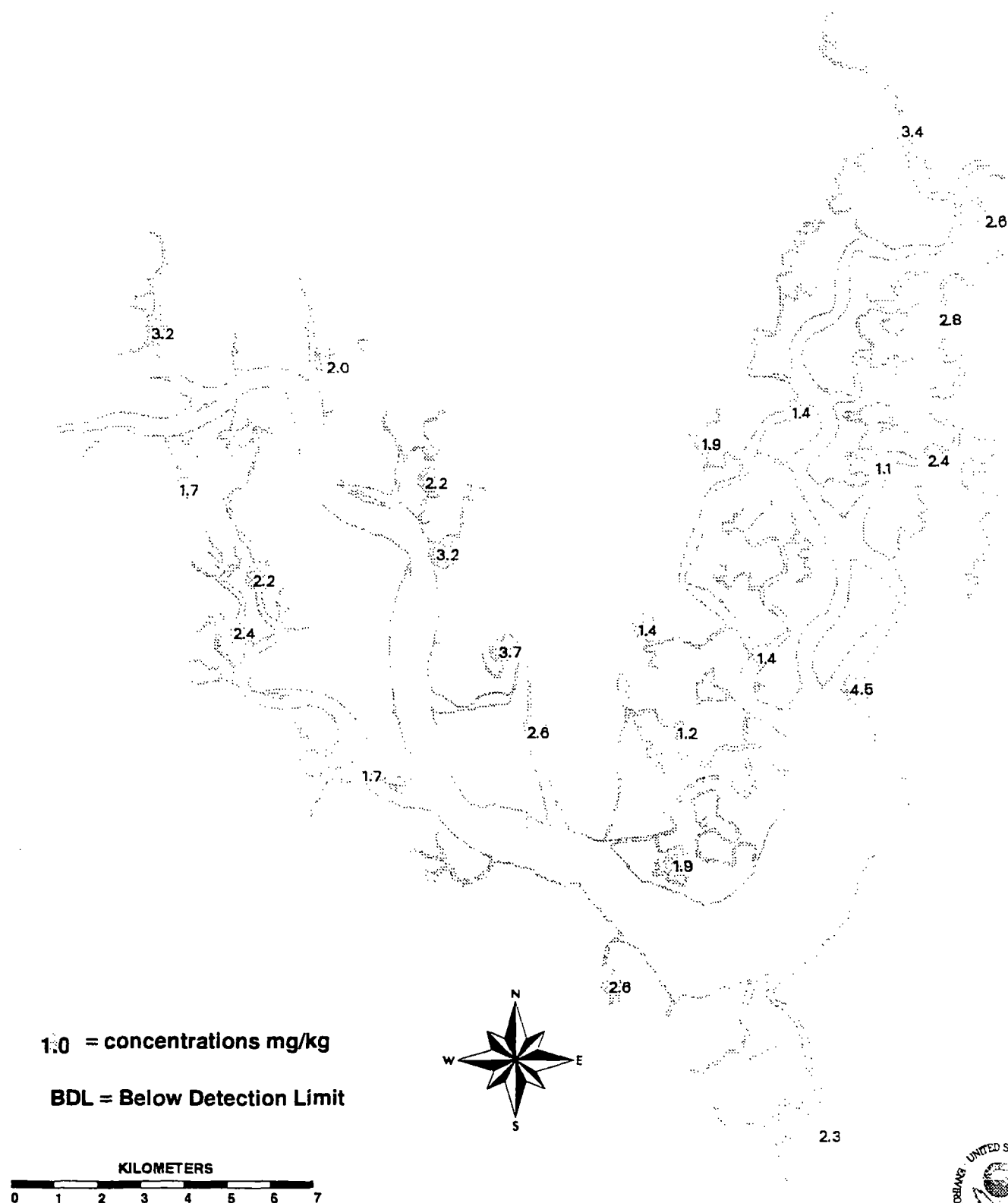


FIGURE 22

# BRUNSWICK COMMUNITY STUDY 12/95

## LEAD IN FISH

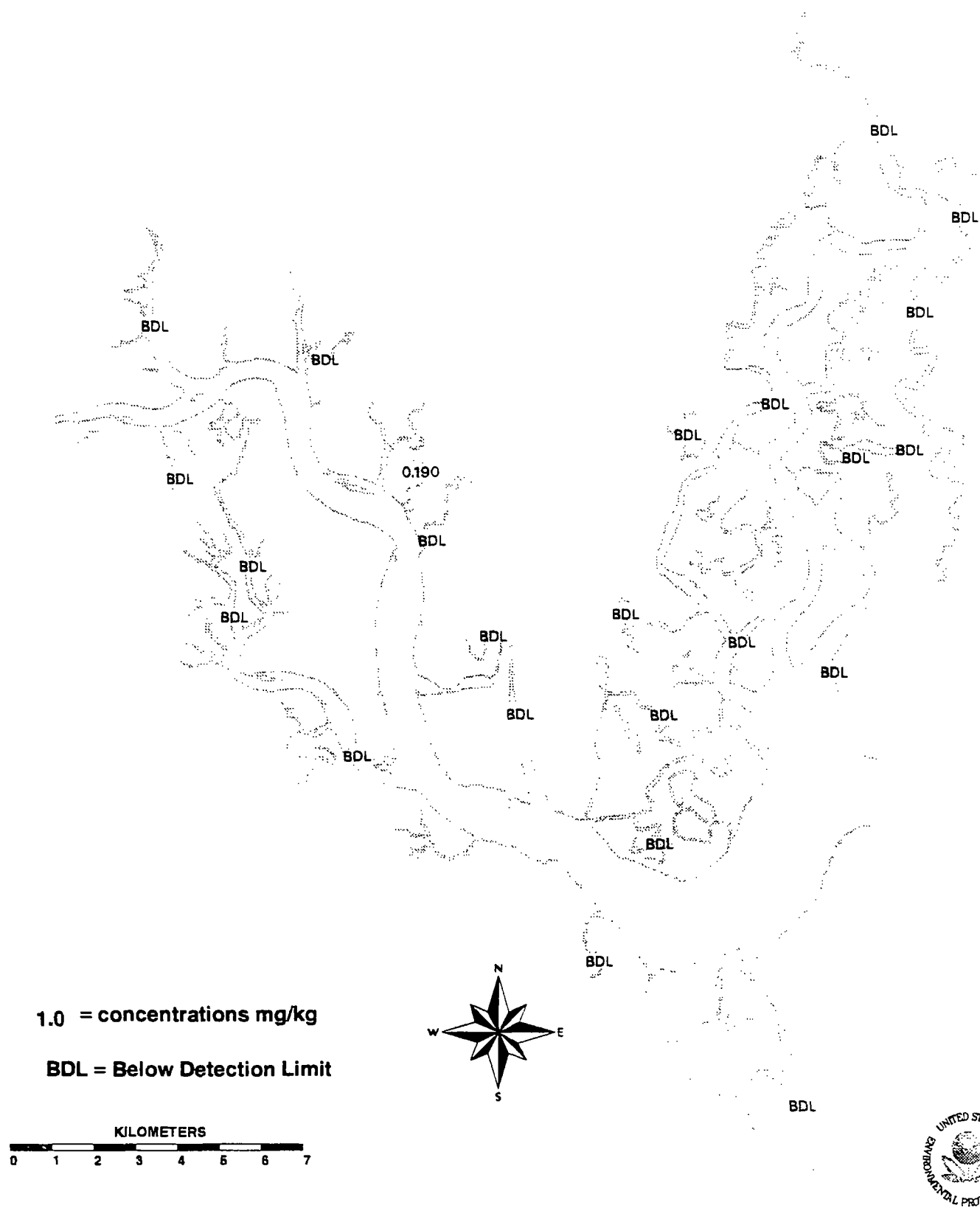


FIGURE 23

# BRUNSWICK COMMUNITY STUDY 12/95

## MERCURY IN FISH

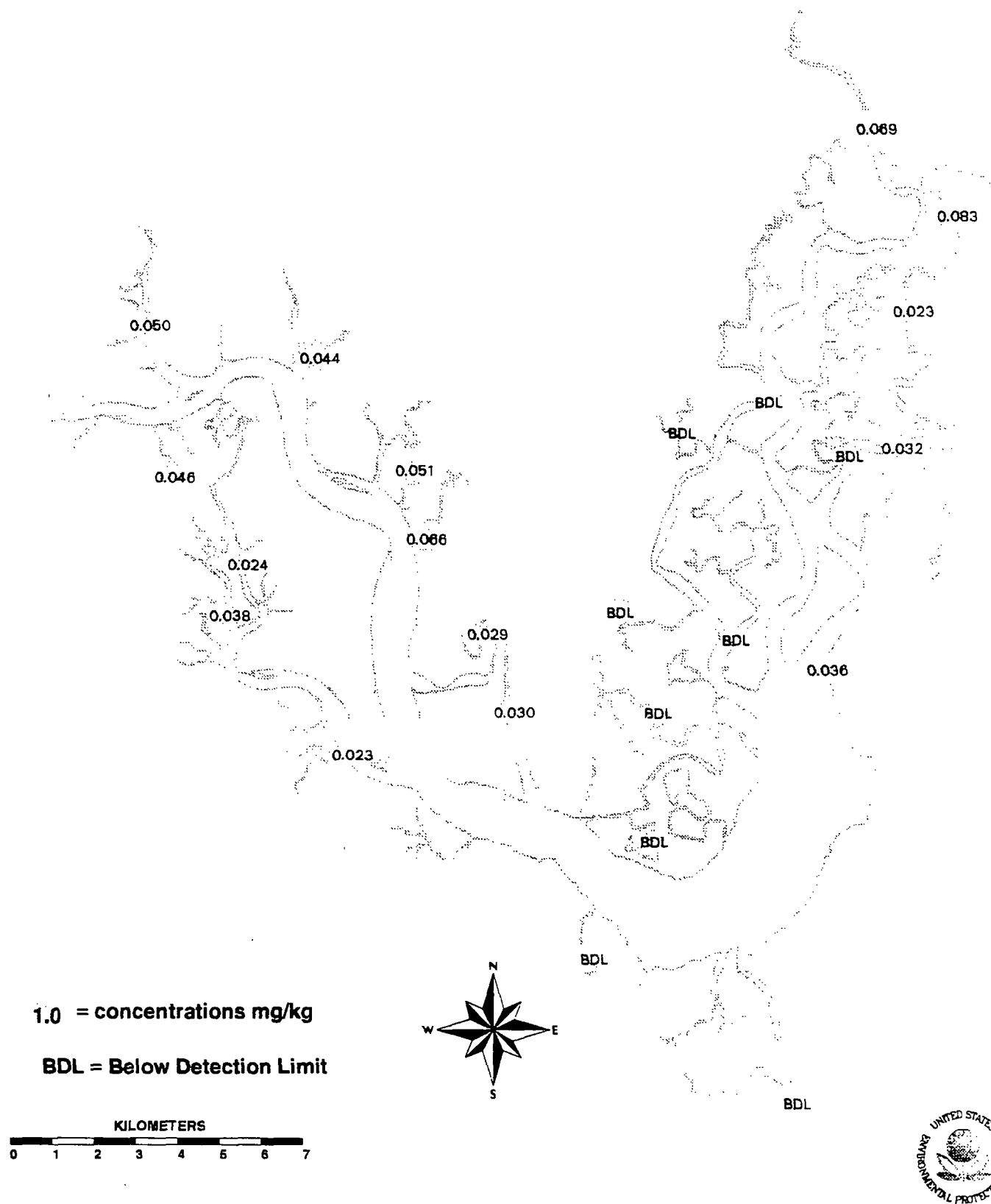
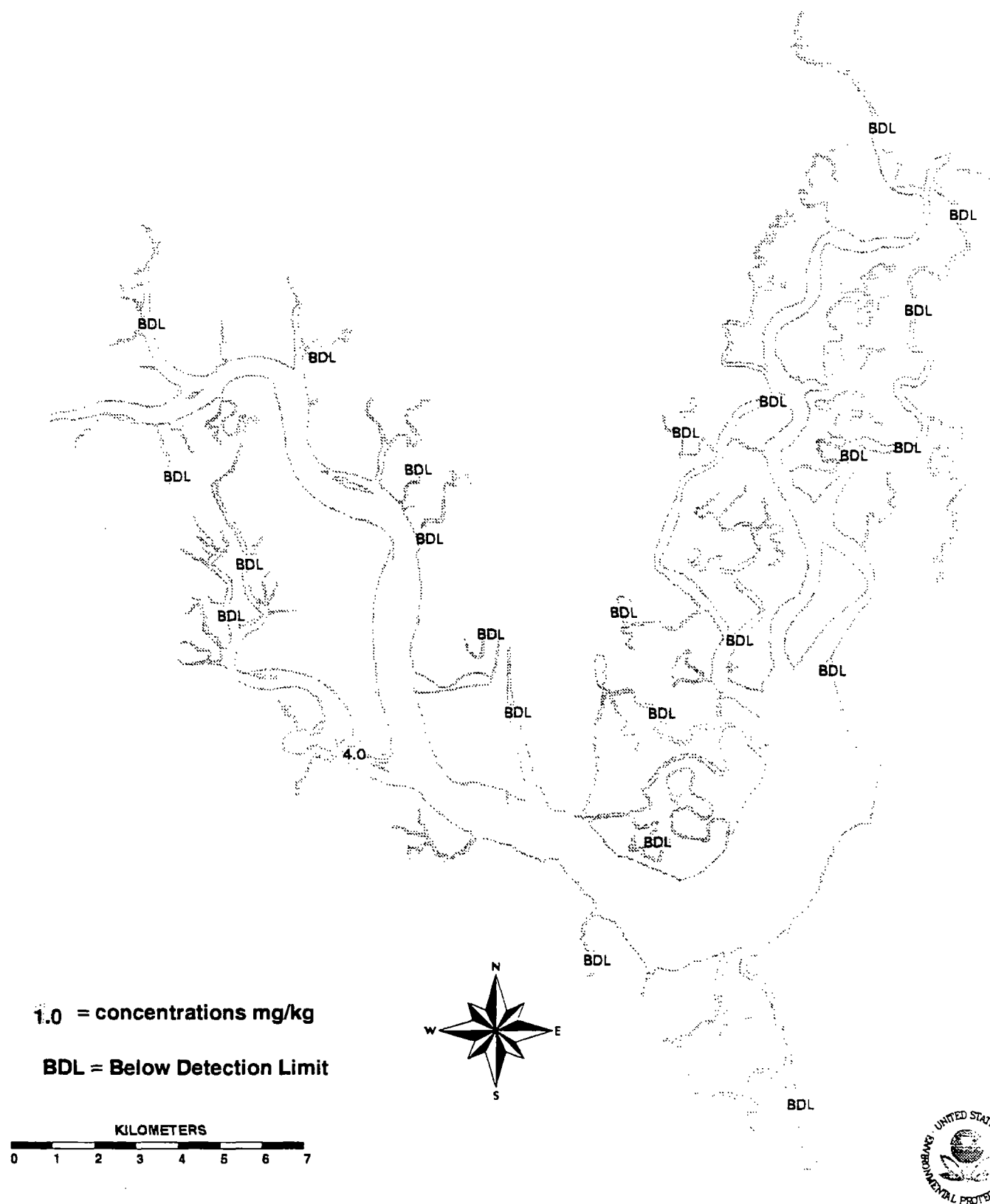


FIGURE 24

## NICKEL IN FISH



**FIGURE 25**



# BRUNSWICK COMMUNITY STUDY 12/95

## ZINC IN FISH

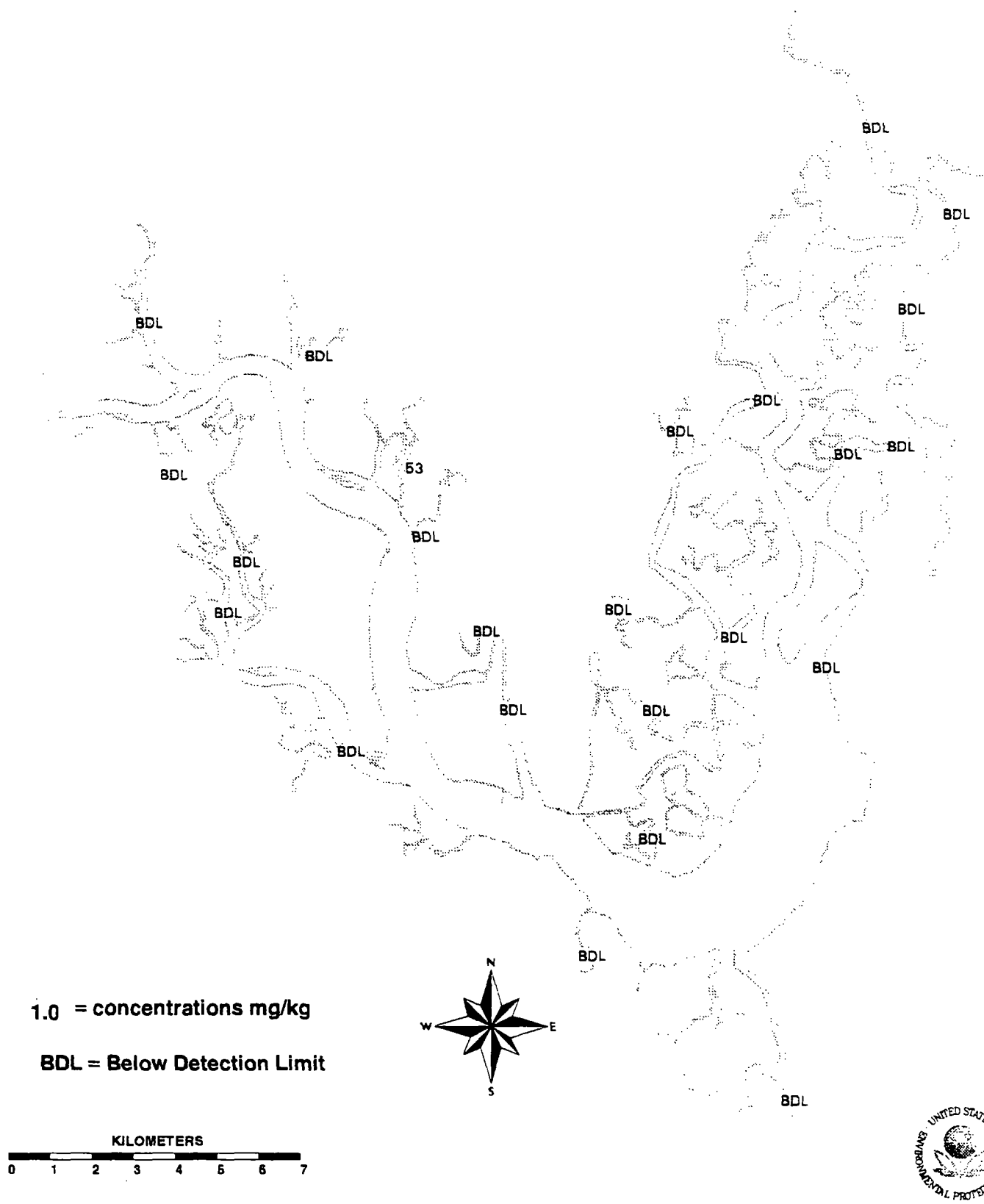


FIGURE 26

# BRUNSWICK COMMUNITY STUDY 12/95

## 2,3,7,8 TETRACHLORODIBENZODIOXIN IN RIVER SEDIMENTS

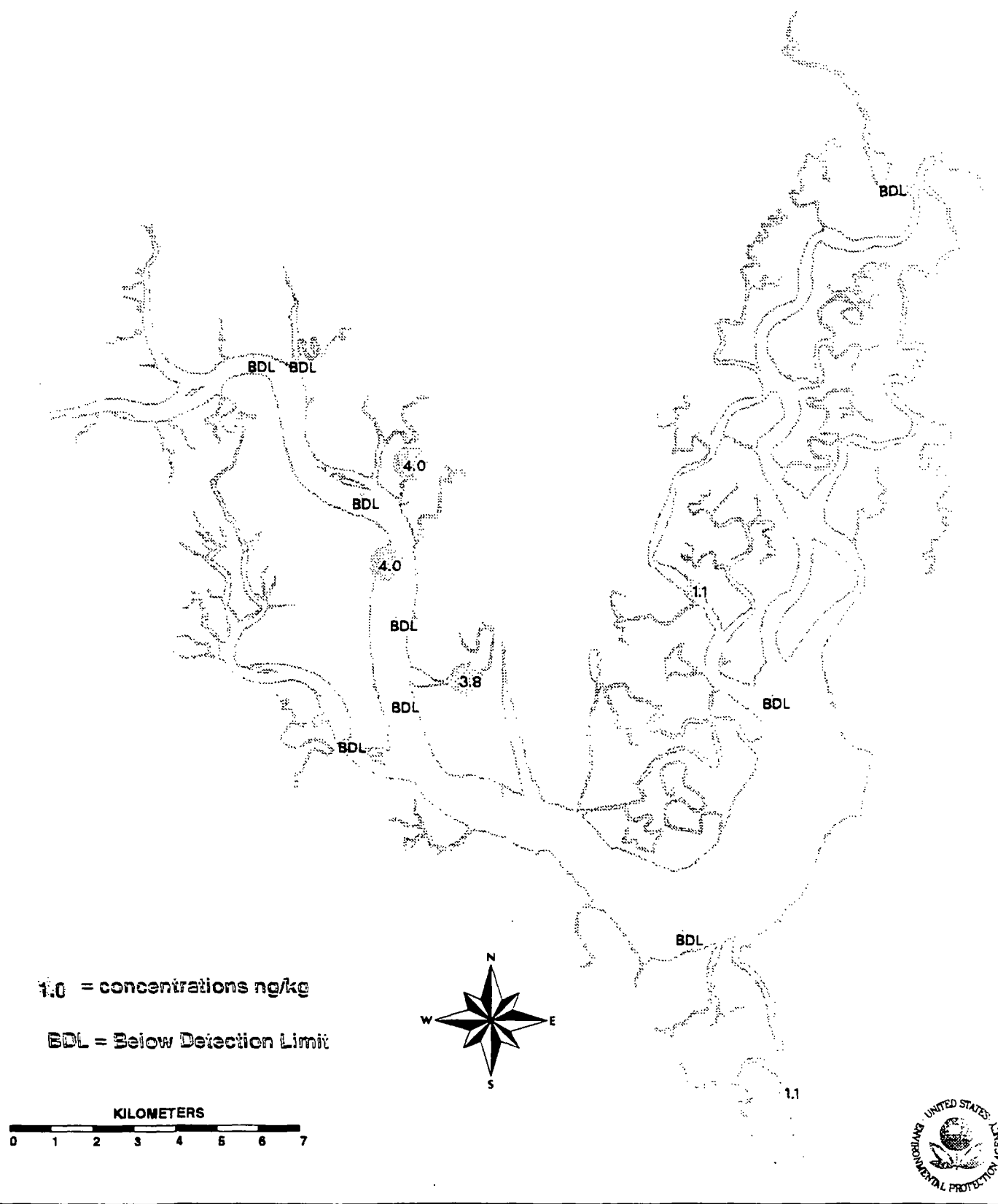


FIGURE 27

# BRUNSWICK COMMUNITY STUDY 12/95

## TETRACHLORODIBENZODIOXIN (TOTAL) IN RIVER SEDIMENTS

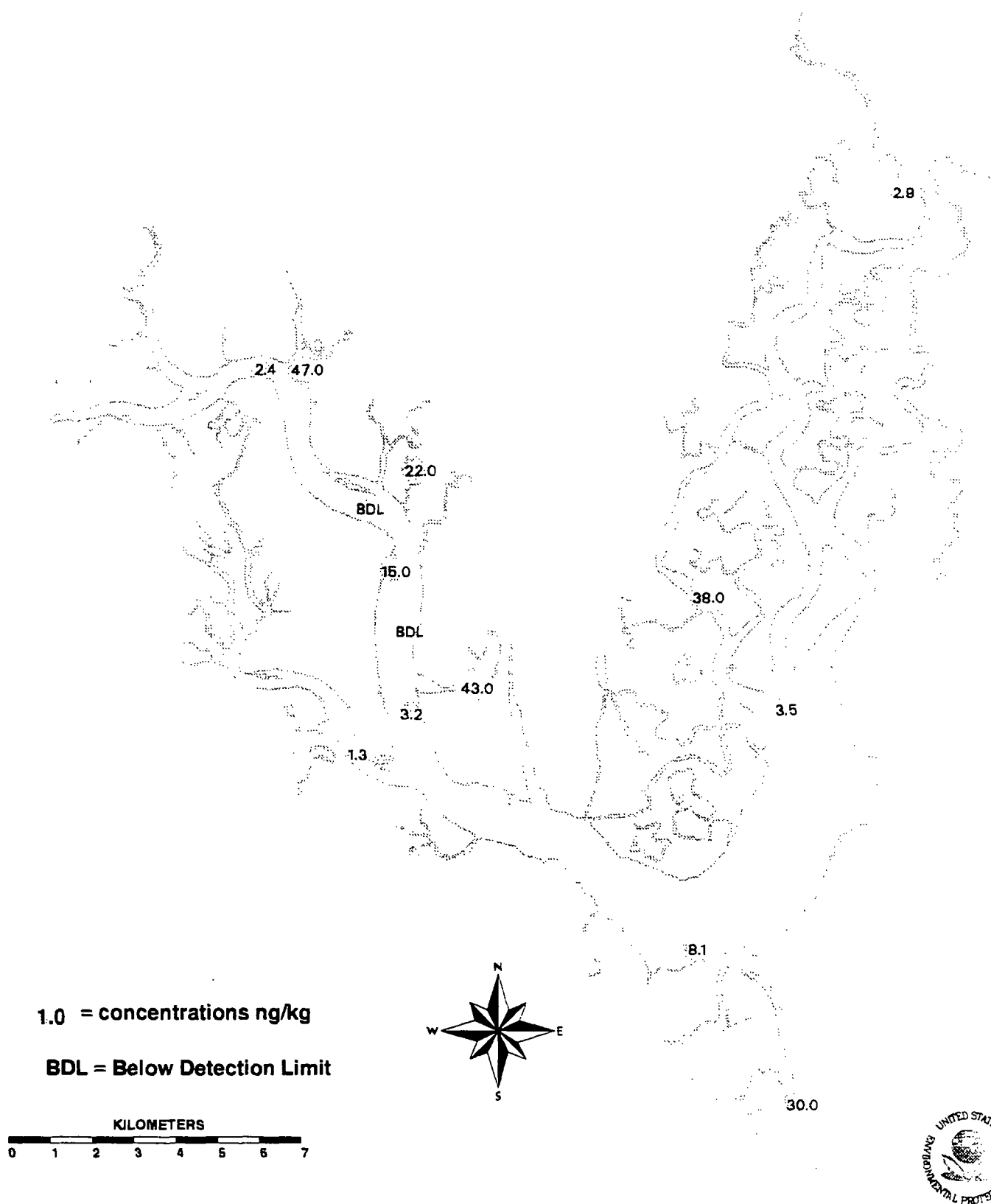


FIGURE 28

# BRUNSWICK COMMUNITY STUDY 12/95

## PENTACHLORODIBENZODIOXIN (TOTAL) IN RIVER SEDIMENTS

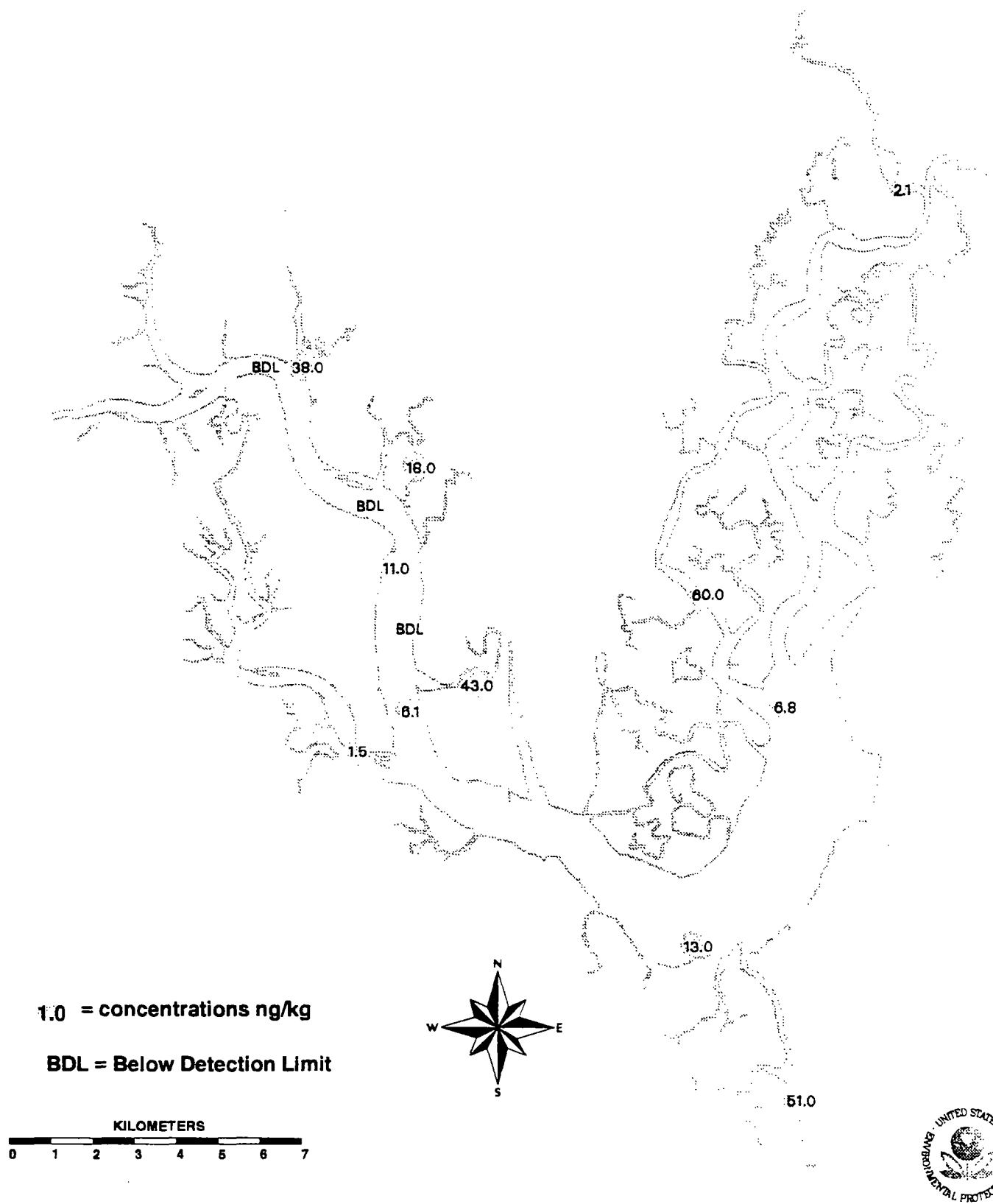


FIGURE 29

# BRUNSWICK COMMUNITY STUDY 12/95

## HEXACHLORODIBENZODIOXIN (TOTAL) IN RIVER SEDIMENTS

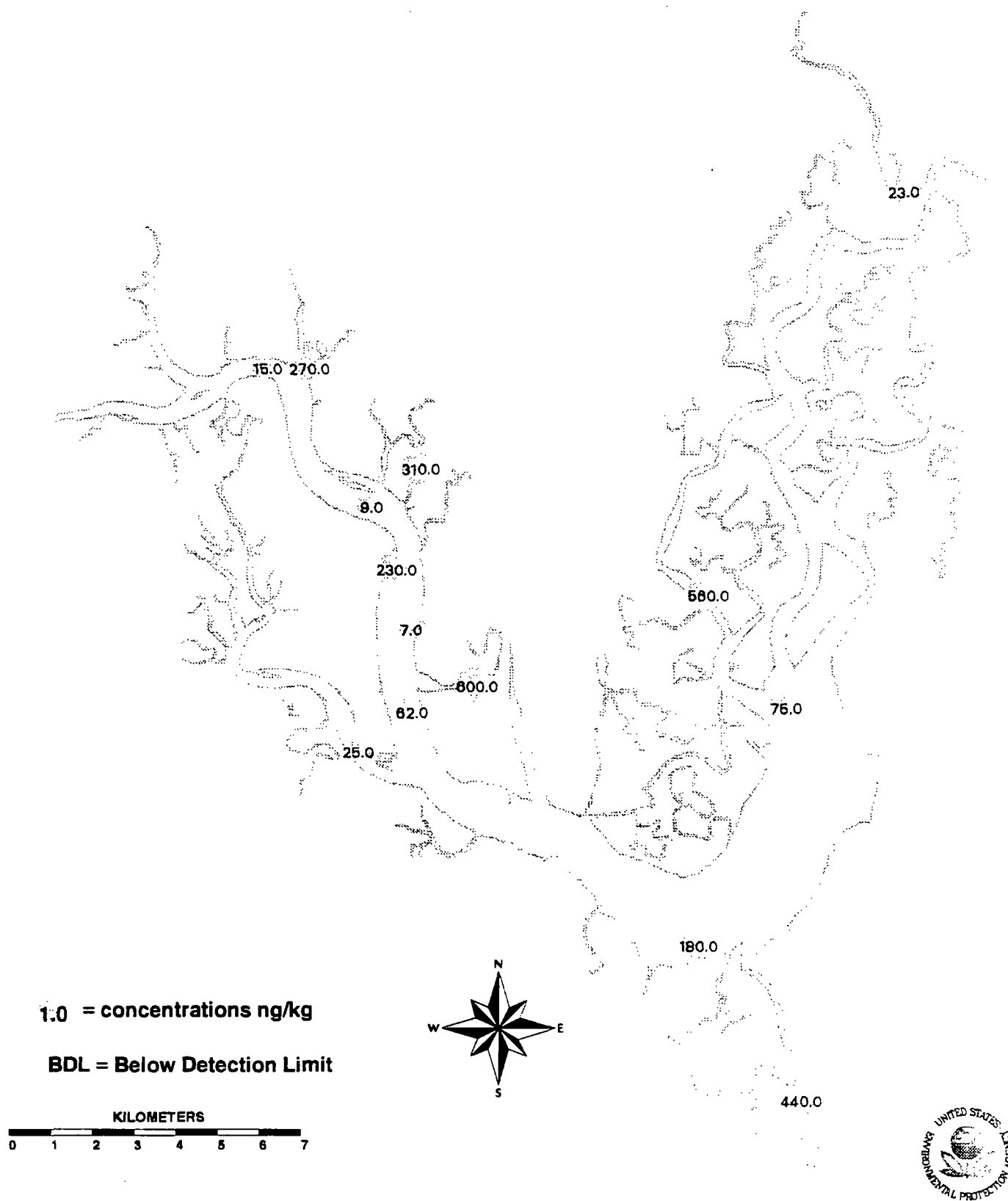


FIGURE 30

# BRUNSWICK COMMUNITY STUDY 12/95

## HEPTACHLORODIBENZODIOXIN (TOTAL) IN RIVER SEDIMENTS

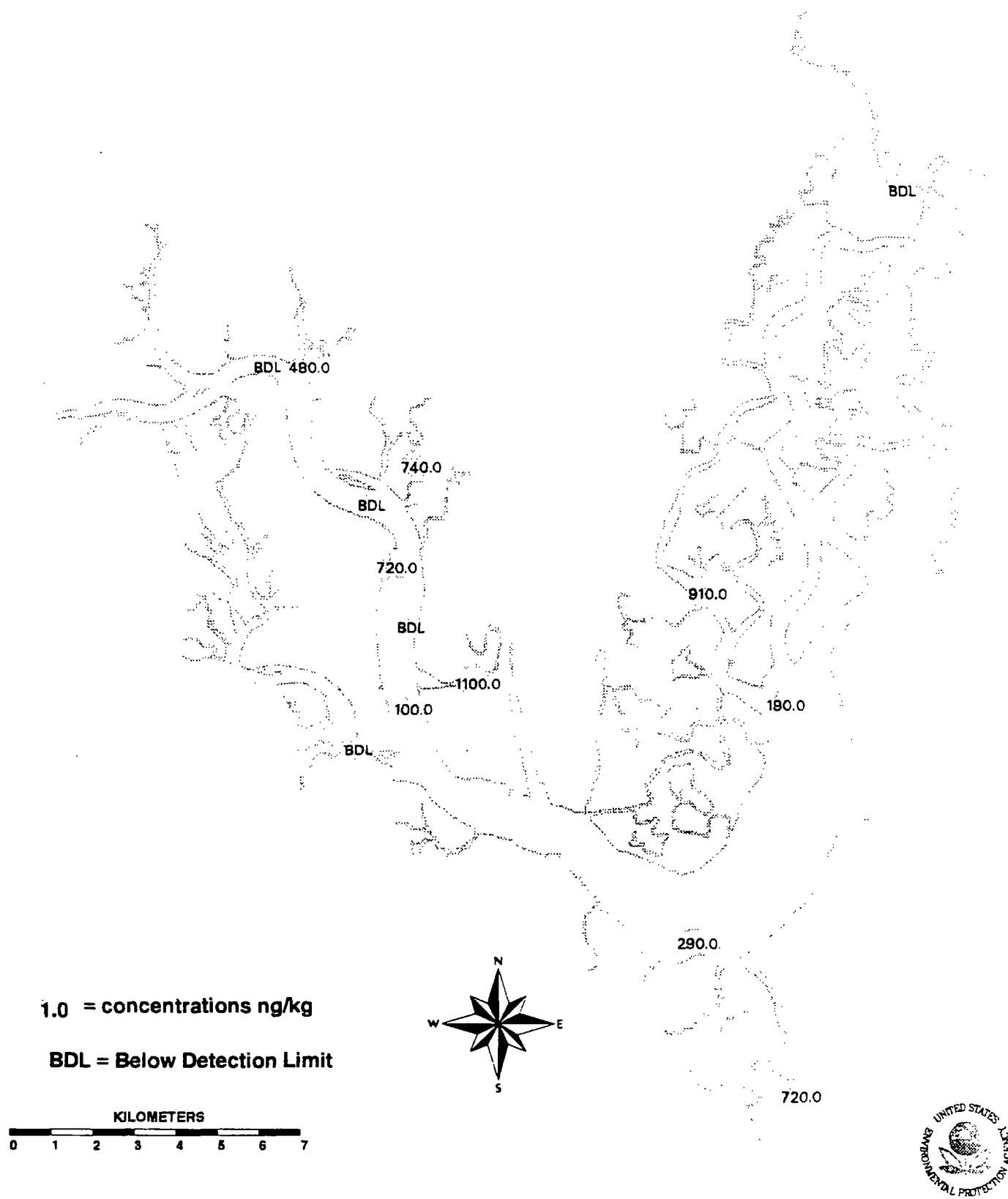


FIGURE 31

# BRUNSWICK COMMUNITY STUDY 12/95

## OCTACHLORODIBENZODIOXIN (TOTAL) IN RIVER SEDIMENTS

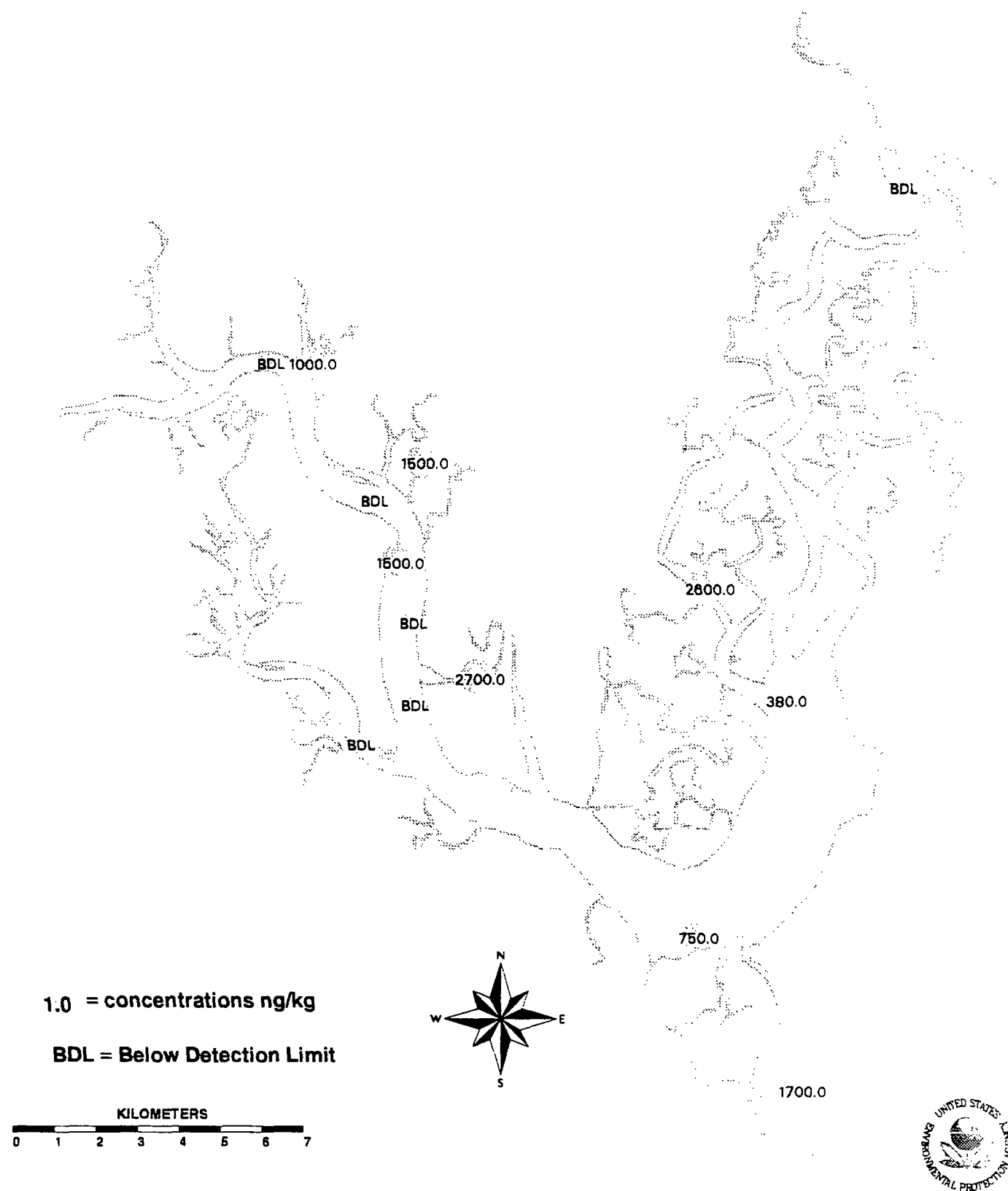


FIGURE 32

# BRUNSWICK COMMUNITY STUDY 12/95

## TETRACHLORODIBENZOFURAN (TOTAL) IN RIVER SEDIMENTS

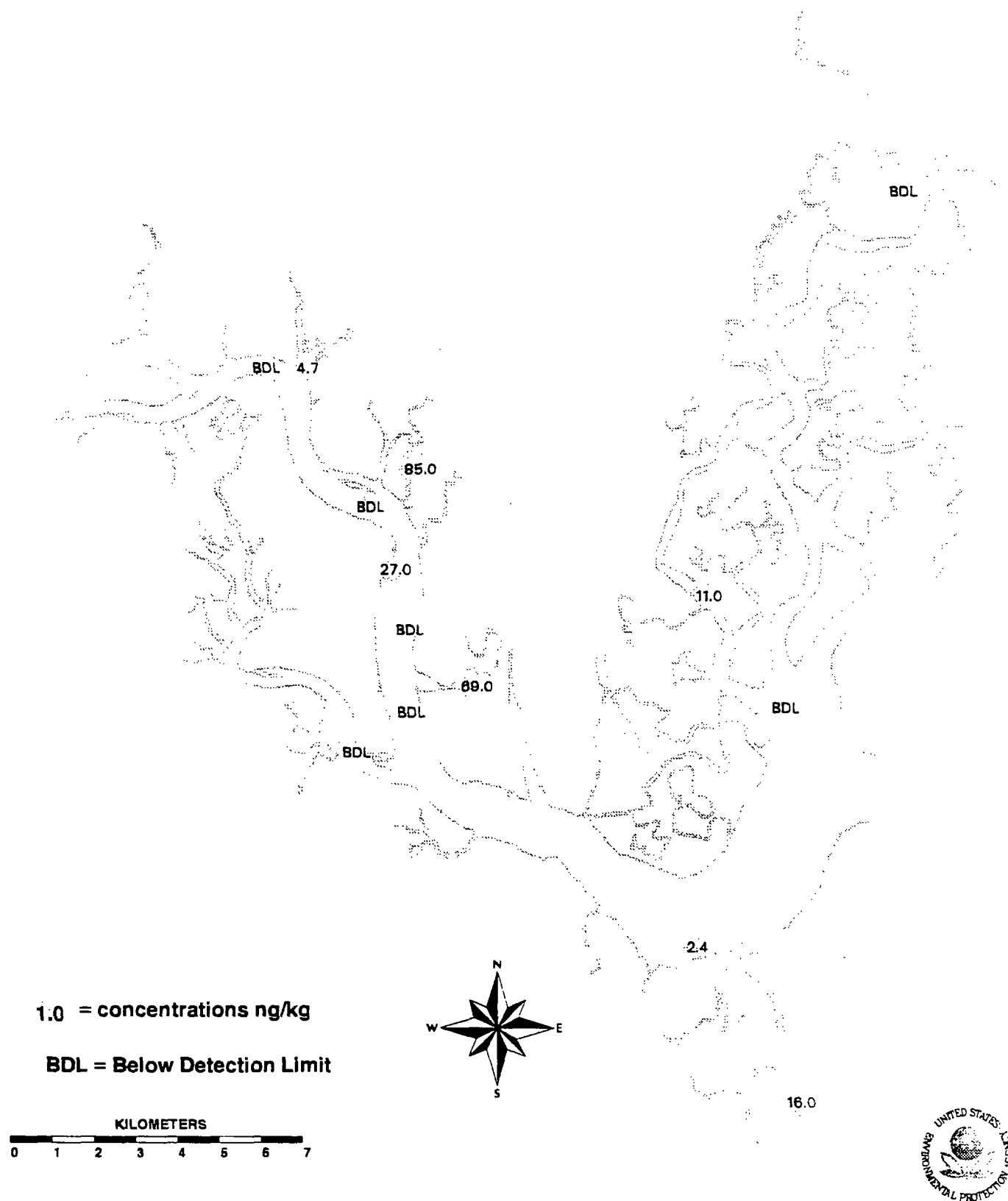


FIGURE 33



# BRUNSWICK COMMUNITY STUDY 12/95

## PENTACHLORODIBENZOFURAN (TOTAL) IN RIVER SEDIMENTS

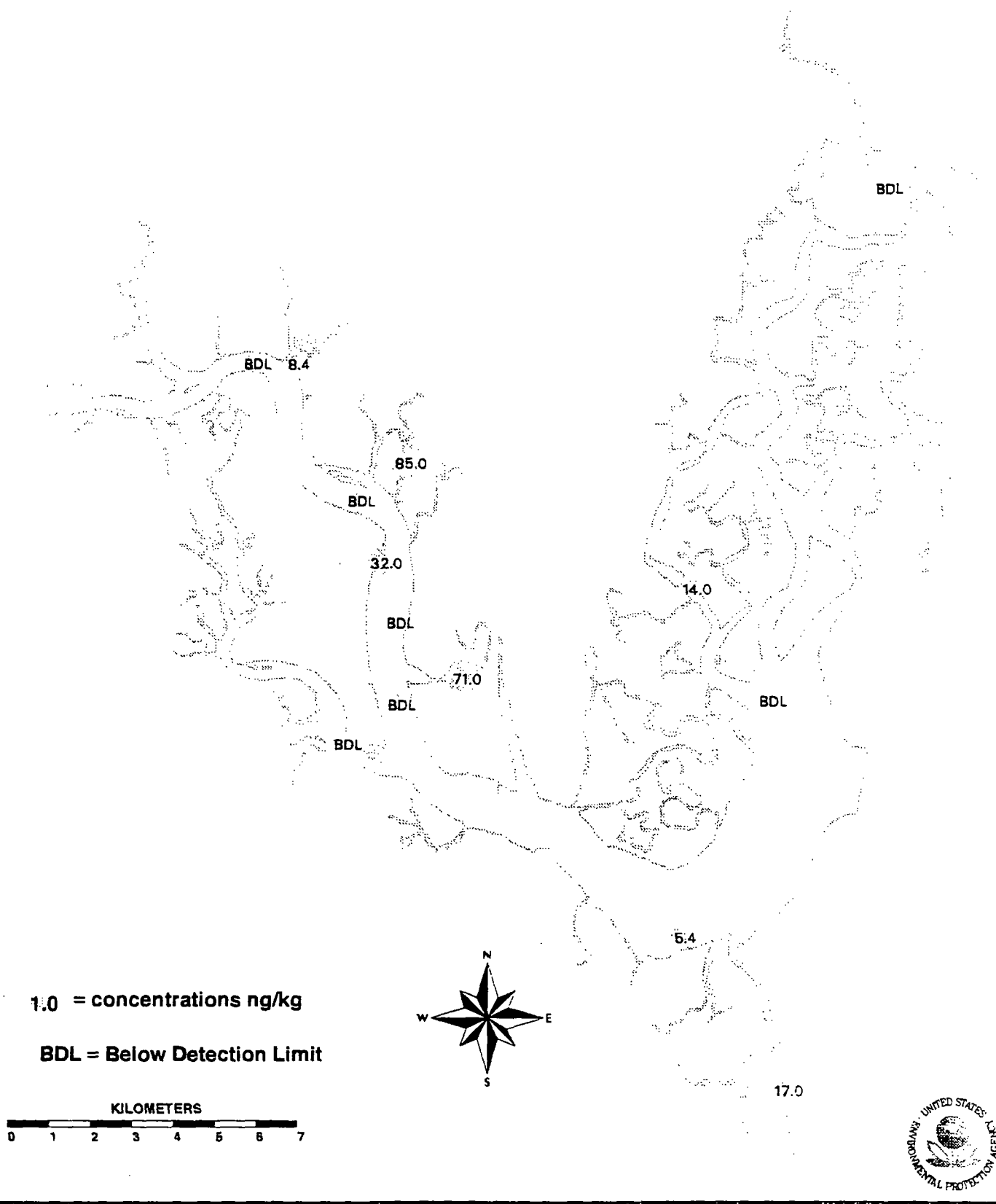


FIGURE 34

# BRUNSWICK COMMUNITY STUDY 12/95

## HEXACHLORODIBENZOFURAN (TOTAL) IN RIVER SEDIMENTS

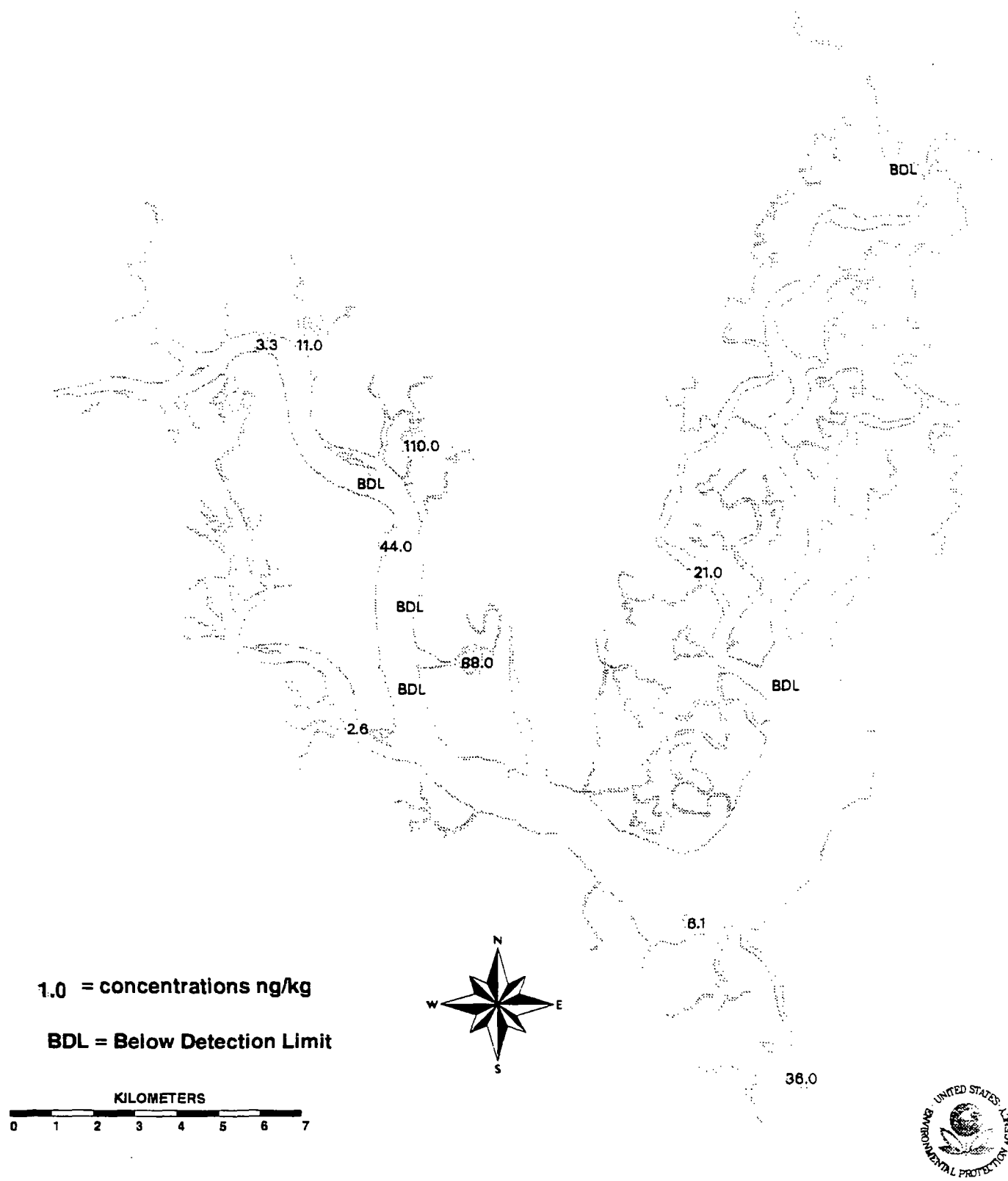


FIGURE 35

# BRUNSWICK COMMUNITY STUDY 12/95

## HEPTACHLORODIBENZOFURAN (TOTAL) IN RIVER SEDIMENTS

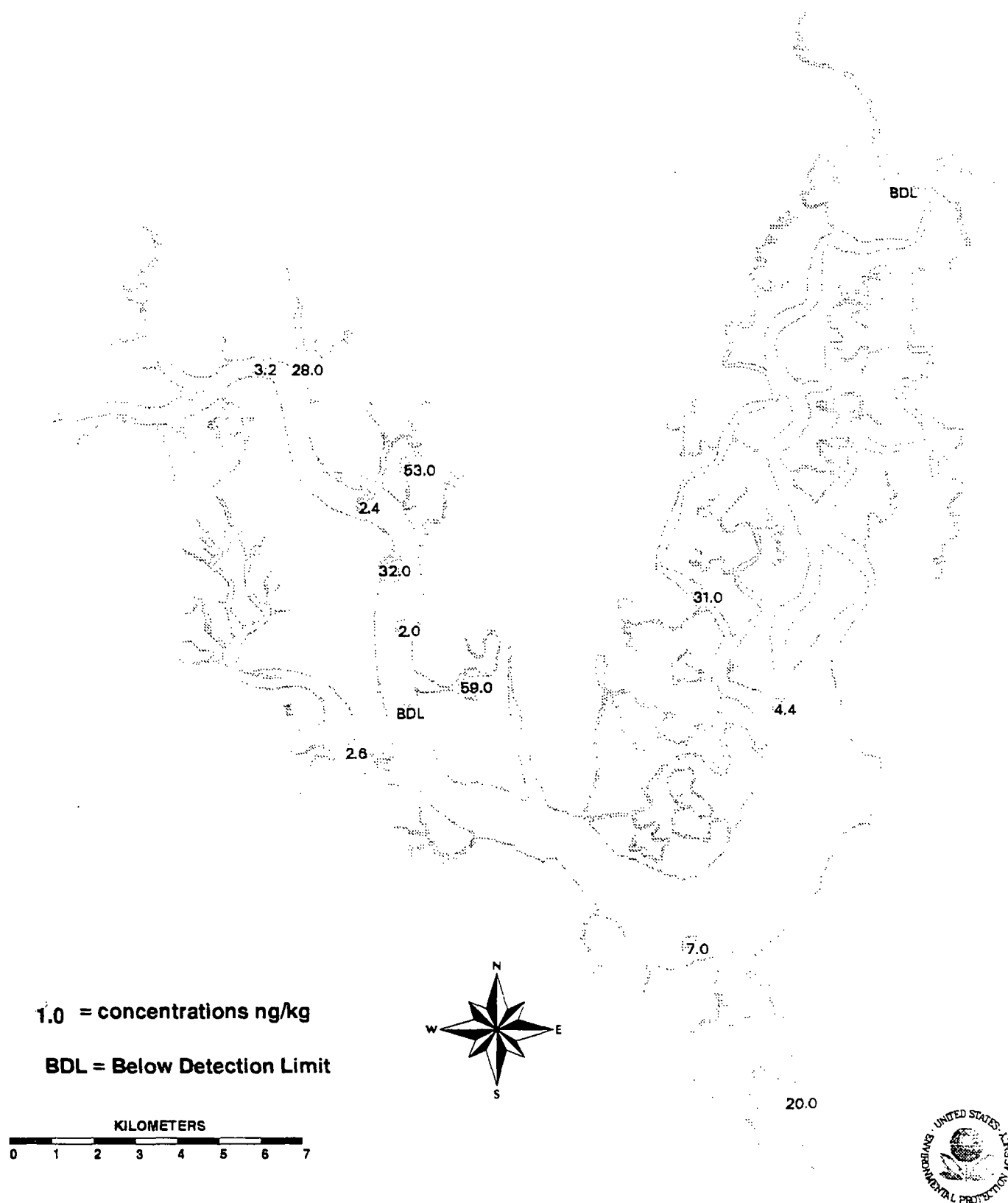


FIGURE 36

# BRUNSWICK COMMUNITY STUDY 12/95

## OCTACHLORODIBENZOFURAN (TOTAL) IN RIVER SEDIMENTS

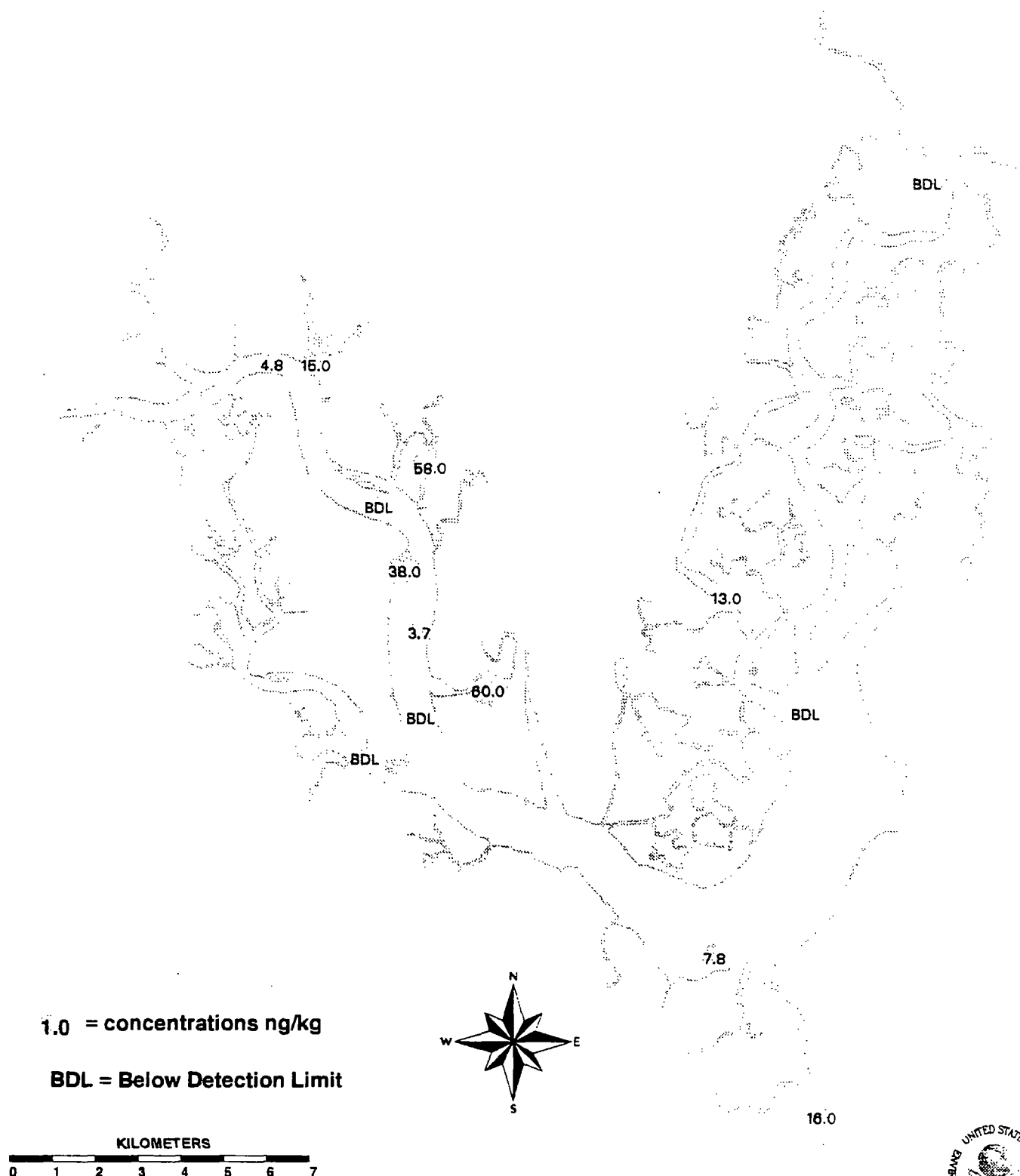


FIGURE 37

## AROCLOR 1268 IN RIVER SEDIMENTS



**FIGURE 38**

# BRUNSWICK COMMUNITY STUDY 12/95

## AROCCLOR 1268 IN MARSH SEDIMENTS

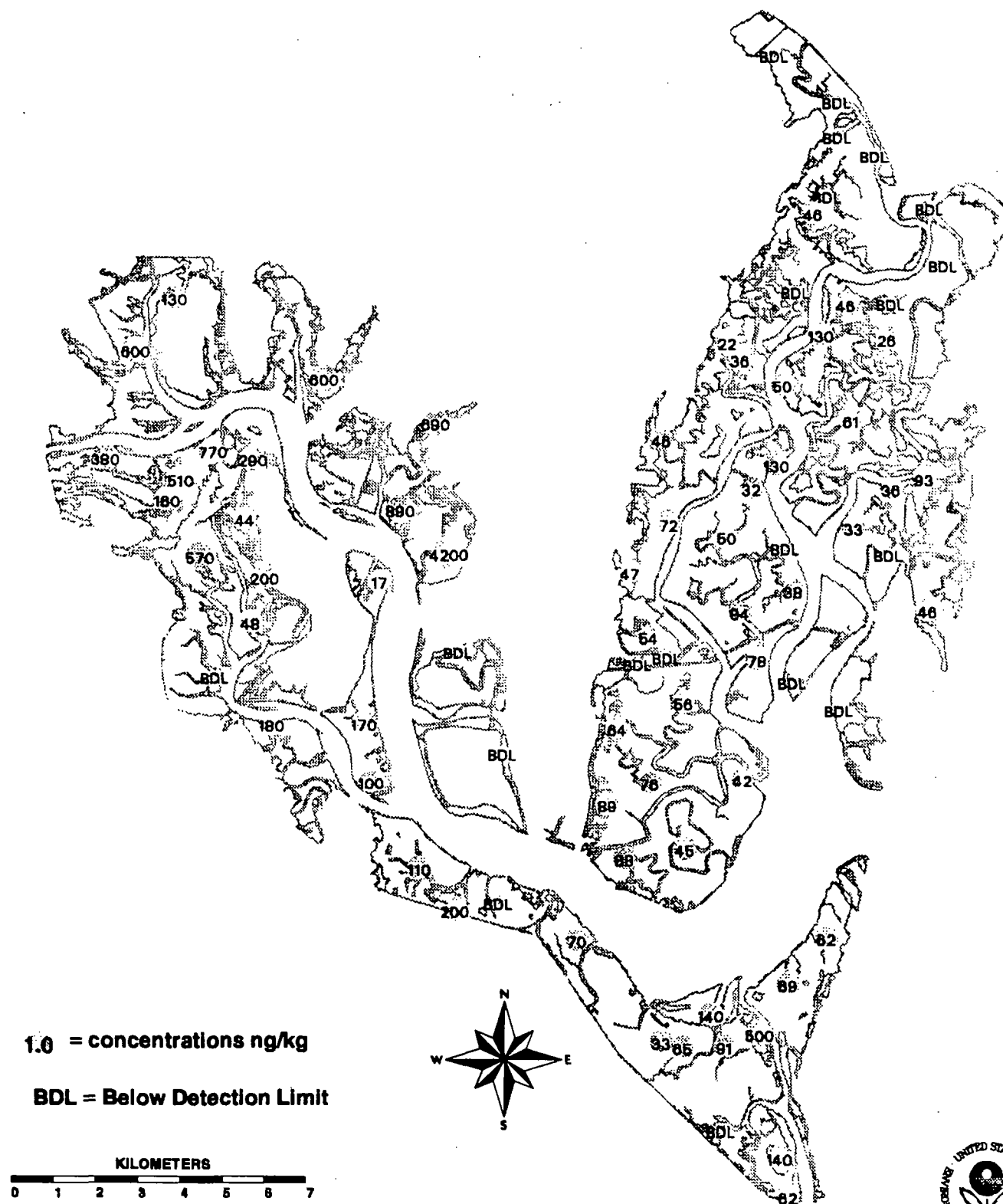


FIGURE 39

# BRUNSWICK COMMUNITY STUDY 12/95

## DIOXIN/FURANS TOXIC EQUIVALENCY VALUES (TEQ)

### IN RIVER SEDIMENTS

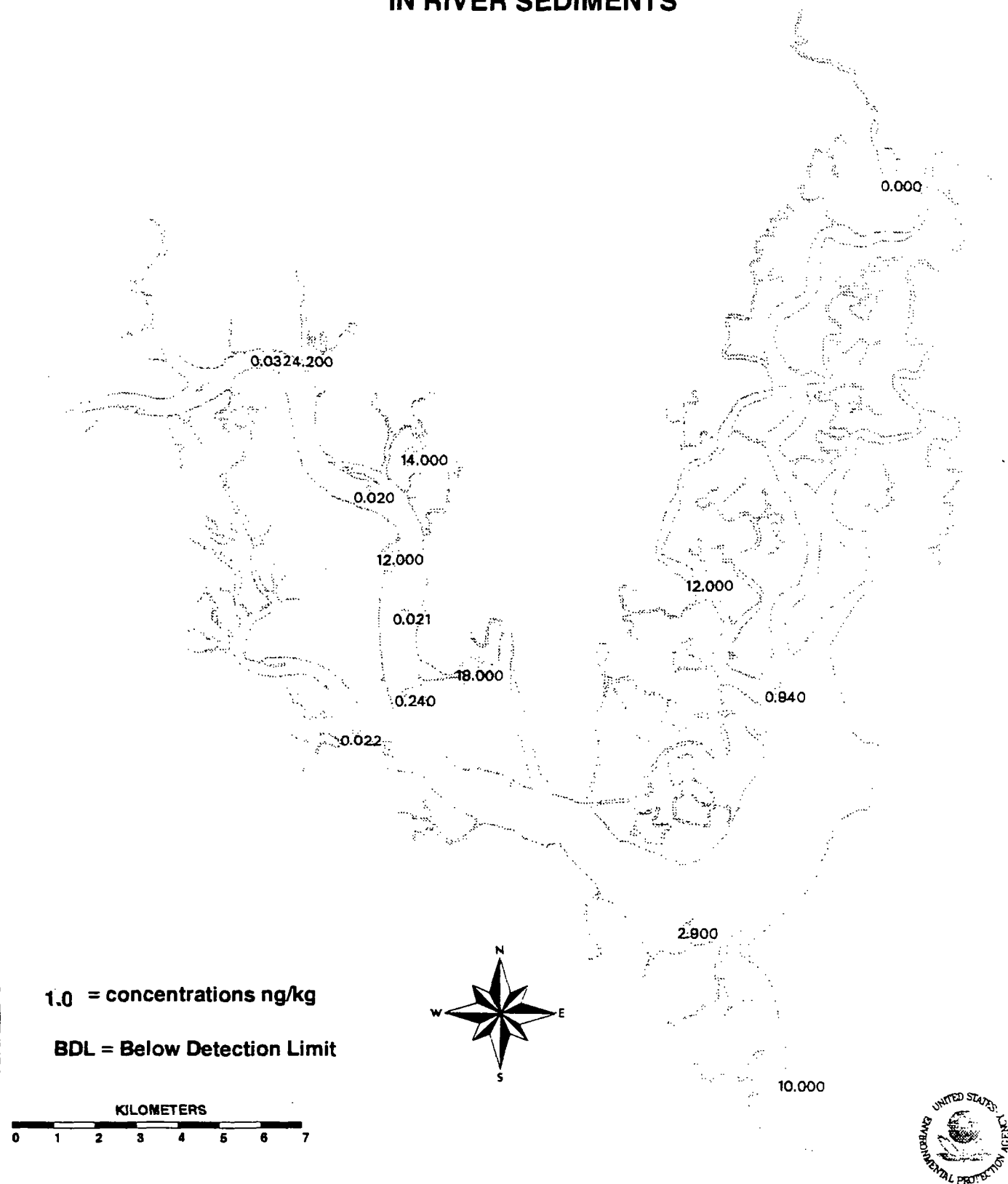


FIGURE 40

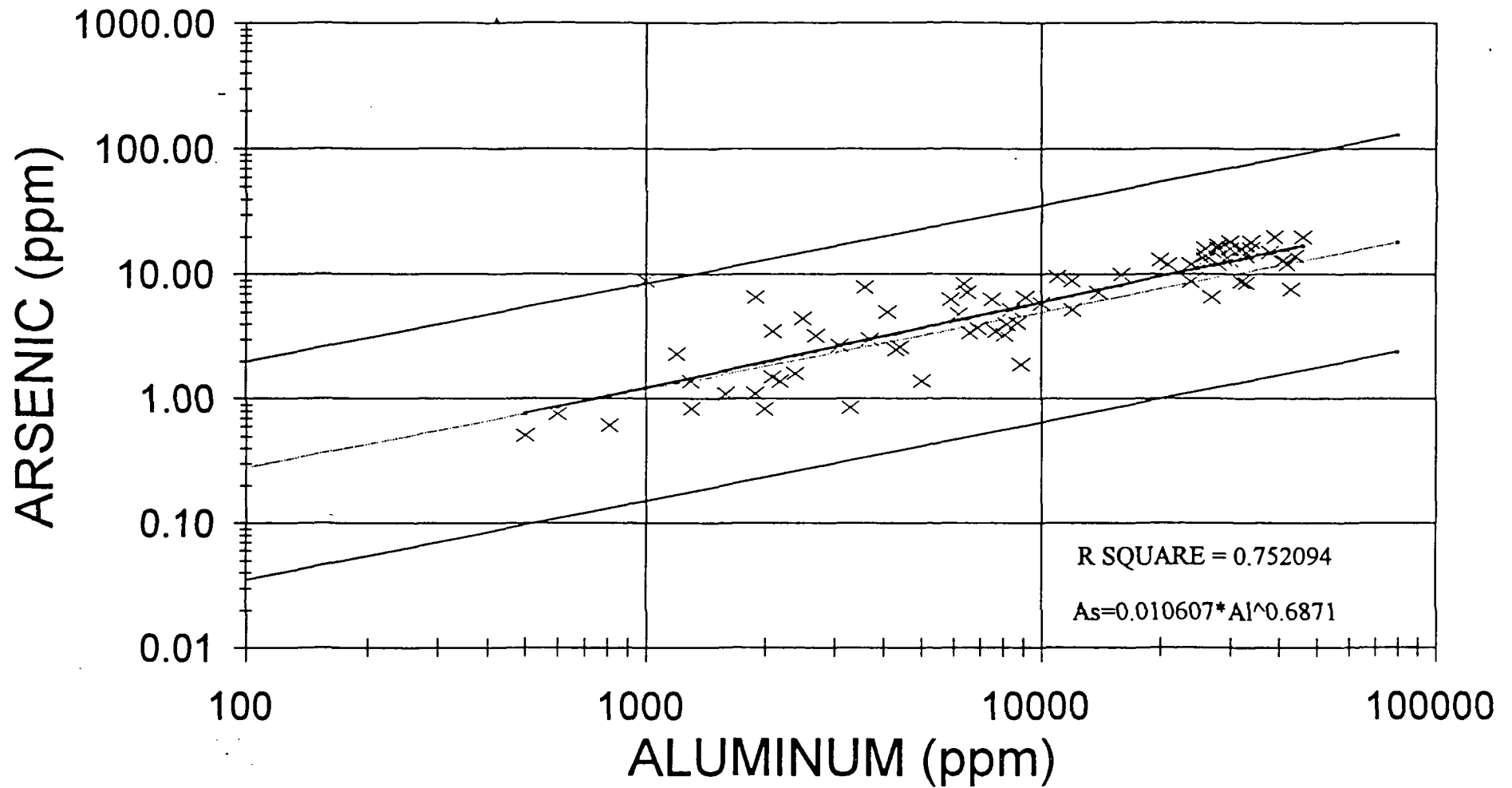
## 6.0 GRAPHS

- GRAPH 1: Arsenic vs Aluminum in River Sediment
- GRAPH 2: Arsenic vs Aluminum in Marsh Sediment
- GRAPH 3: Chromium vs Aluminum in River Sediment
- GRAPH 4: Chromium vs Aluminum in Marsh Sediment
- GRAPH 5: Copper vs Aluminum in River Sediment
- GRAPH 6: Copper vs Aluminum in Marsh Sediment
- GRAPH 7: Lead vs Aluminum in River Sediment
- GRAPH 8: Lead vs Aluminum in Marsh Sediment
- GRAPH 9: Nickel vs Aluminum in River Sediment
- GRAPH 10: Nickel vs Aluminum in Marsh Sediment
- GRAPH 11: Zinc vs Aluminum in River Sediment
- GRAPH 12: Zinc vs Aluminum in Marsh Sediment
- GRAPH 13: Arsenic vs Total Organic Material in River Sediment
- GRAPH 14: Chromium vs Total Organic Material in River Sediment
- GRAPH 15: Copper vs Total Organic Material in River Sediment
- GRAPH 16: Lead vs Total Organic Material in River Sediment
- GRAPH 17: Mercury vs Total Organic Material in River Sediment
- GRAPH 18: Nickel vs Total Organic Material in River Sediment
- GRAPH 19: Zinc vs Total Organic Material in River Sediment
- GRAPH 20: Cumulative Distribution Frequency Curve for Arsenic in River Sediment
- GRAPH 21: Cumulative Distribution Frequency Curve for Arsenic in Marsh Sediment
- GRAPH 22: Cumulative Distribution Frequency Curve for Chromium in River Sediment
- GRAPH 23: Cumulative Distribution Frequency Curve for Chromium in Marsh Sediment
- GRAPH 24: Cumulative Distribution Frequency Curve for Copper in River Sediment
- GRAPH 25: Cumulative Distribution Frequency Curve for Copper in Marsh Sediment
- GRAPH 26: Cumulative Distribution Frequency Curve for Lead in River Sediment
- GRAPH 27: Cumulative Distribution Frequency Curve for Lead in Marsh Sediment
- GRAPH 28: Cumulative Distribution Frequency Curve for Mercury in River Sediment
- GRAPH 29: Cumulative Distribution Frequency Curve for Mercury in Marsh Sediment
- GRAPH 30: Cumulative Distribution Frequency Curve for Nickel in River Sediment
- GRAPH 31: Cumulative Distribution Frequency Curve for Nickel in Marsh Sediment
- GRAPH 32: Cumulative Distribution Frequency Curve for Zinc in River Sediment
- GRAPH 33: Cumulative Distribution Frequency Curve for Zinc in Marsh Sediment
- GRAPH 34: Cumulative Distribution Frequency Curve for Aroclor 1268 in River Sediment
- GRAPH 35: Cumulative Distribution Frequency Curve for Aroclor 1268 in Marsh Sediment



# BRUNSWICK COMMUNITY STUDY 12/95

## RIVER SEDIMENT - ARSENIC / ALUMINUM

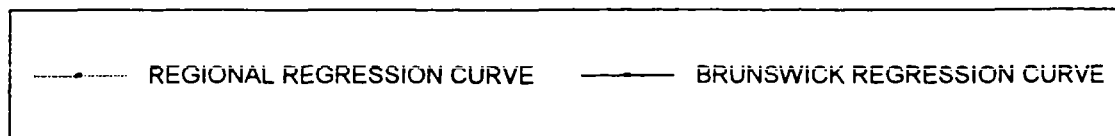
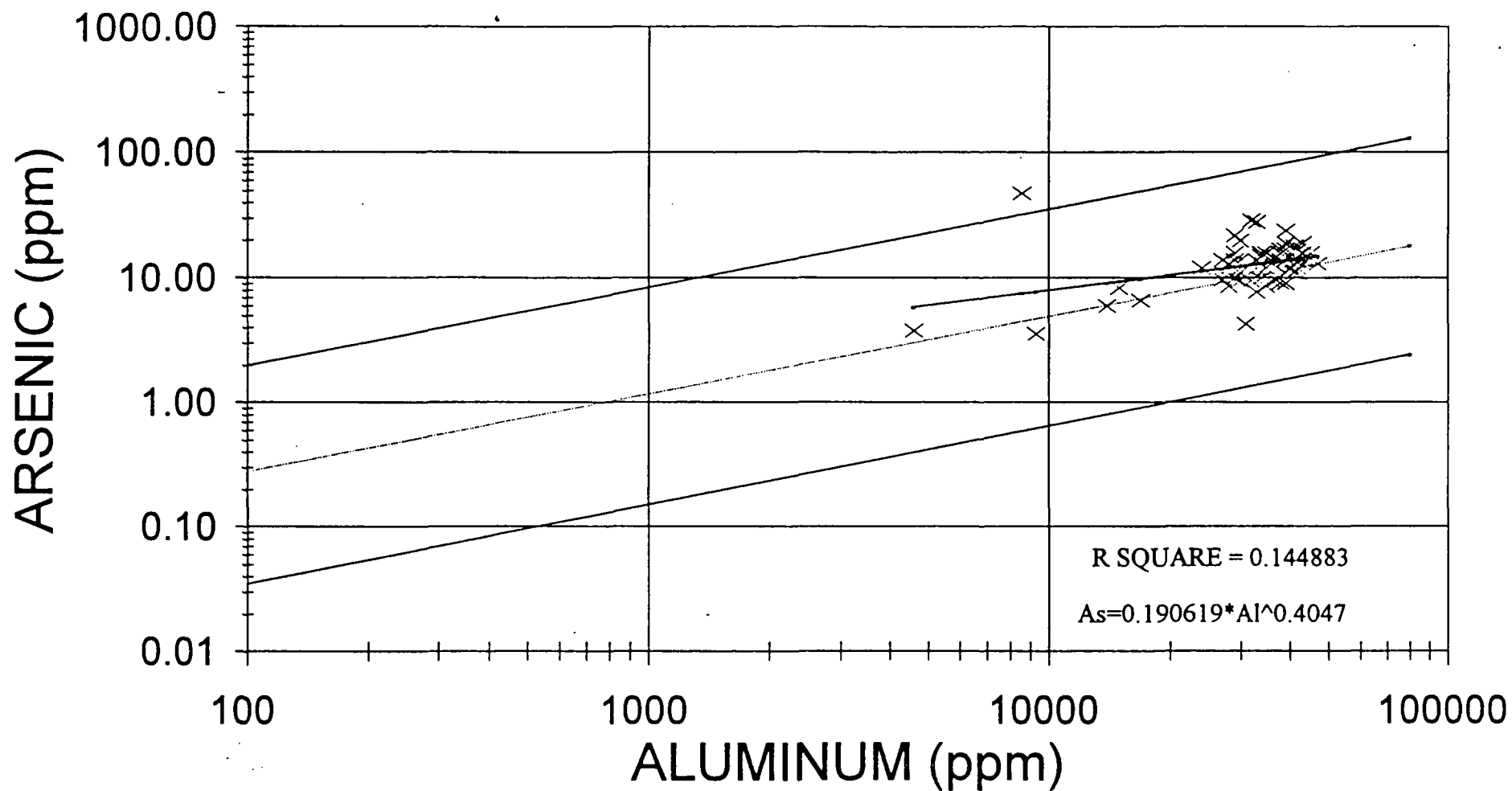


----- REGIONAL REGRESSION CURVE      ——— BRUNSWICK REGRESSION CURVE

GRAPH 1

# BRUNSWICK COMMUNITY STUDY 12/95

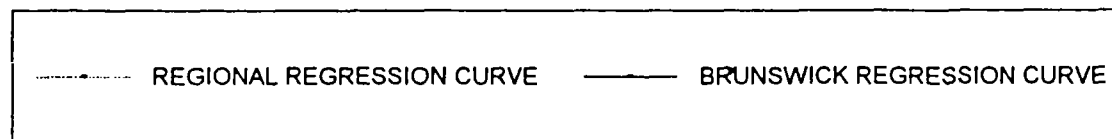
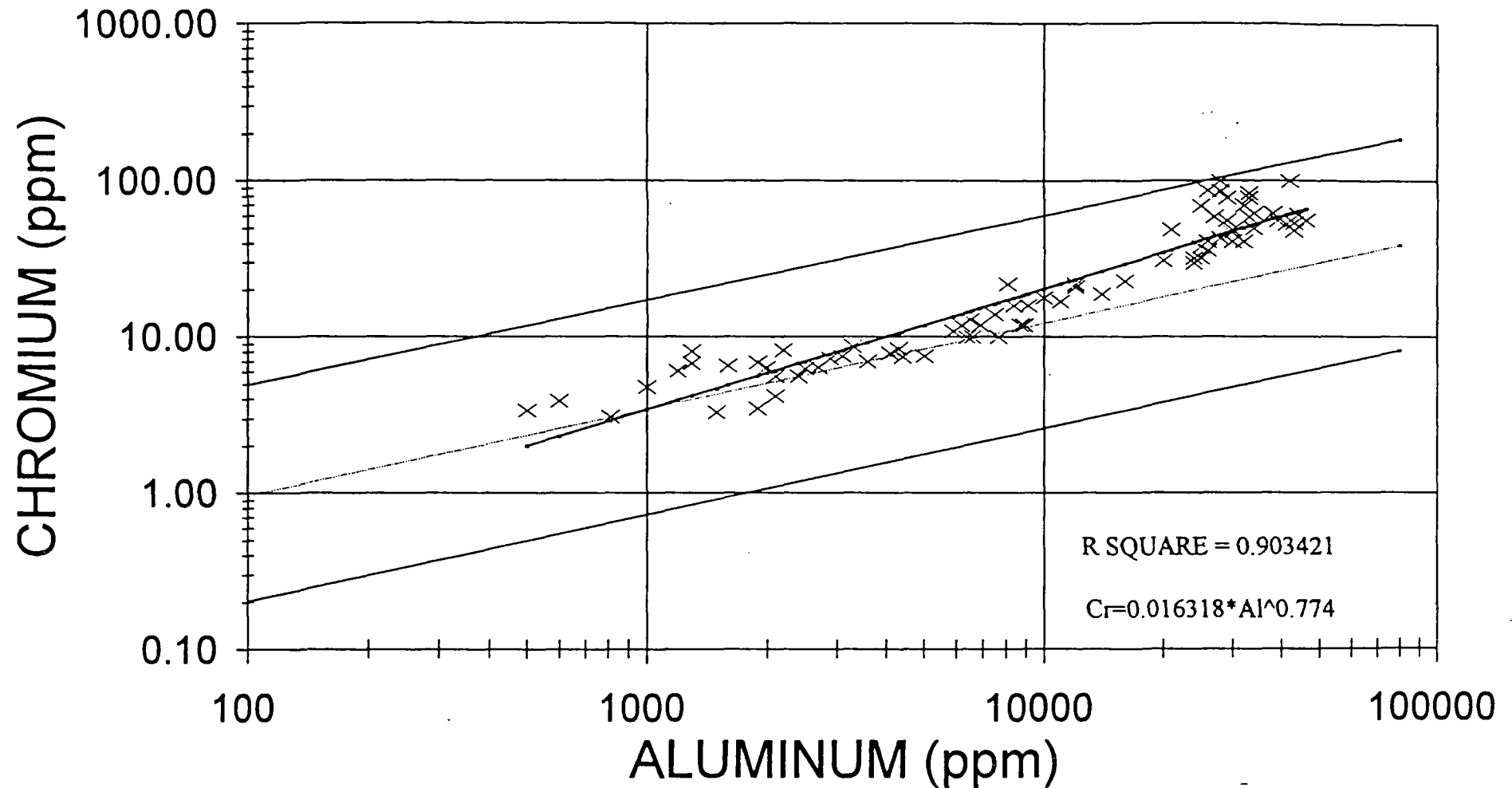
## MARSH SEDIMENT - ARSENIC / ALUMINUM



GRAPH 2

# BRUNSWICK COMMUNITY STUDY 12/95

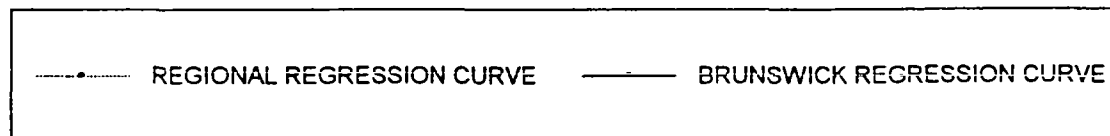
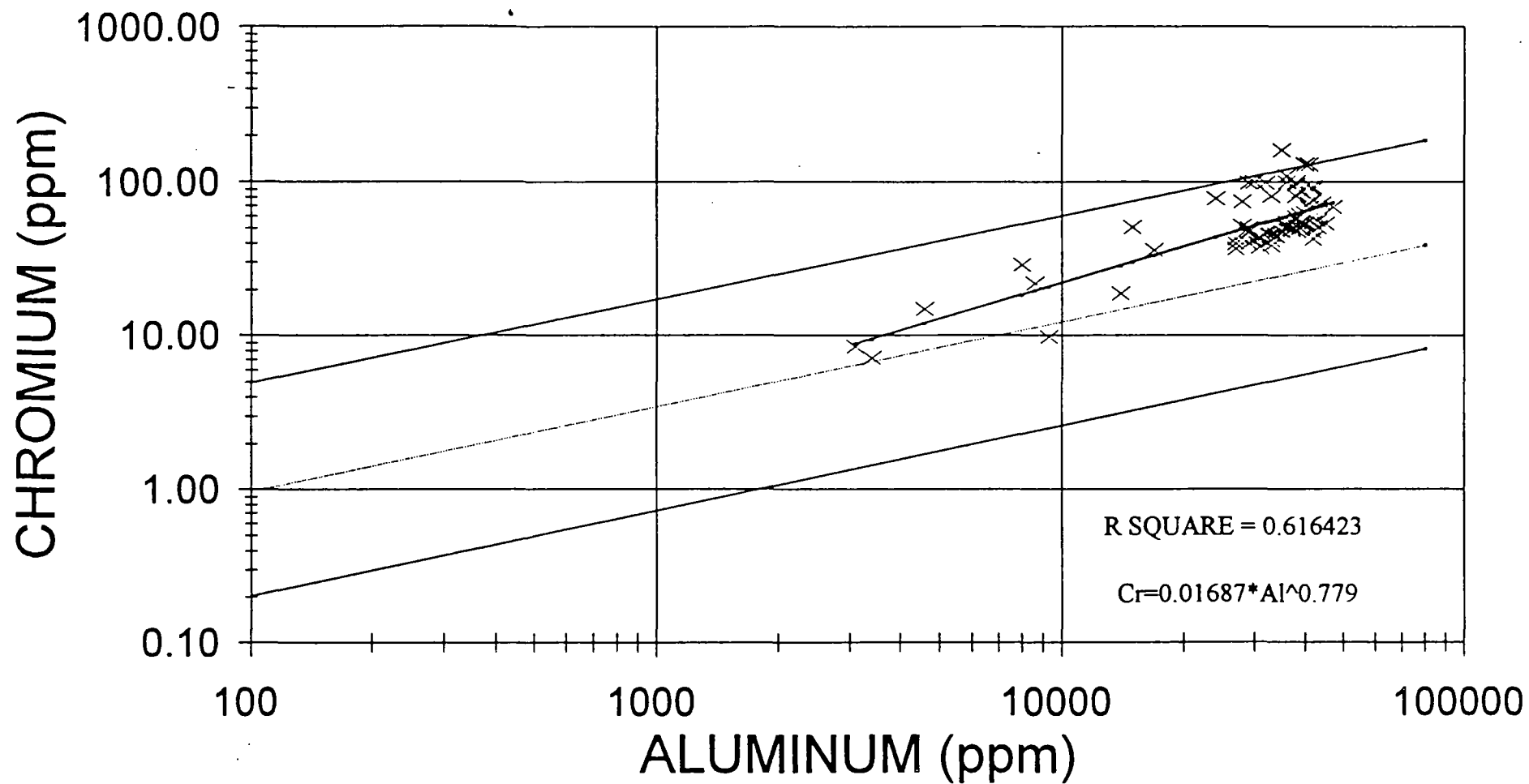
## RIVER SEDIMENT - CHROMIUM / ALUMINUM



GRAPH 3

# BRUNSWICK COMMUNITY STUDY 12/95

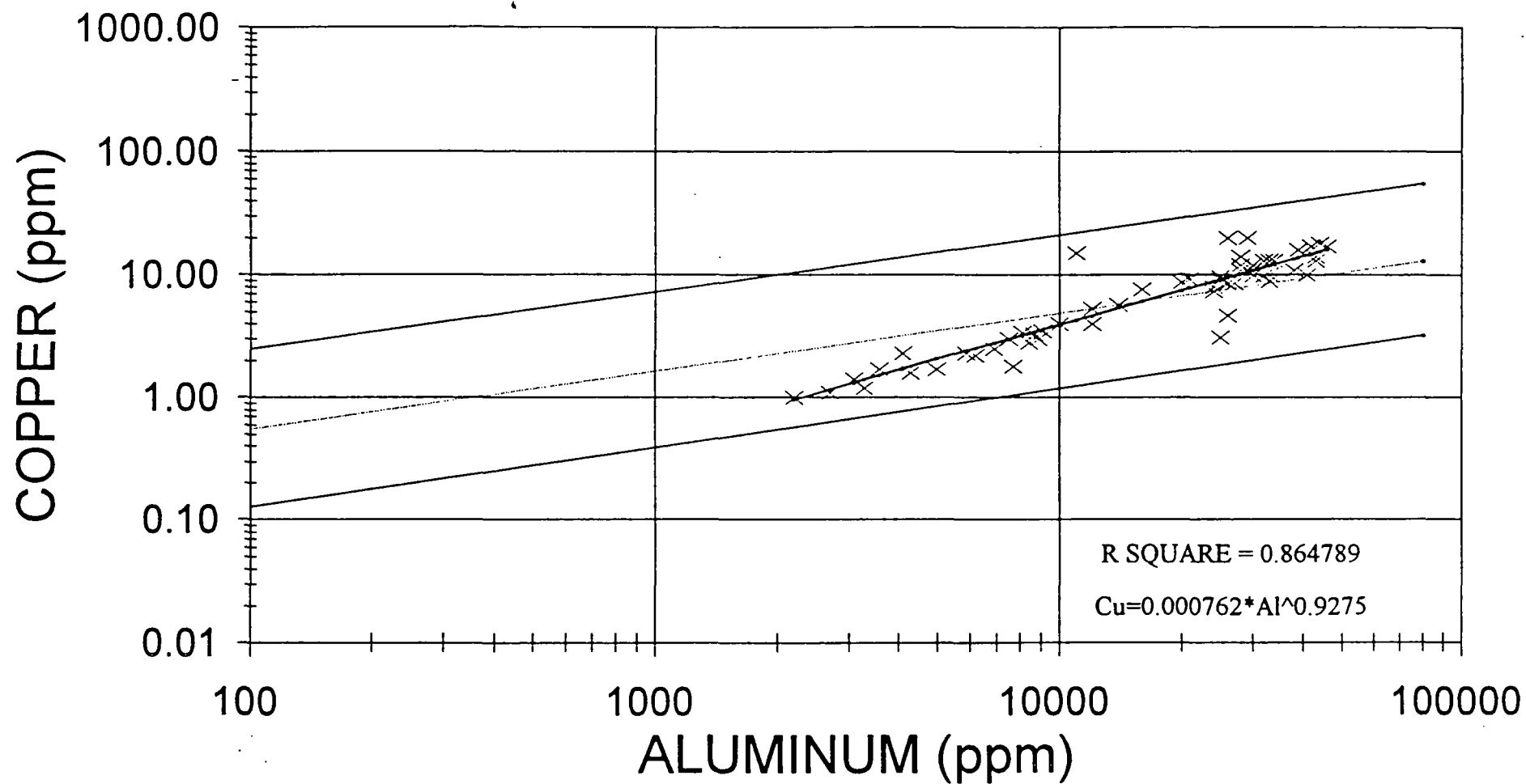
## MARSH SEDIMENT - CHROMIUM / ALUMINUM



GRAPH 4

# BRUNSWICK COMMUNITY STUDY 12/95

## RIVER SEDIMENT - COPPER / ALUMINUM

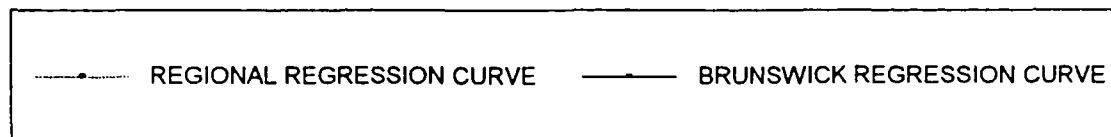
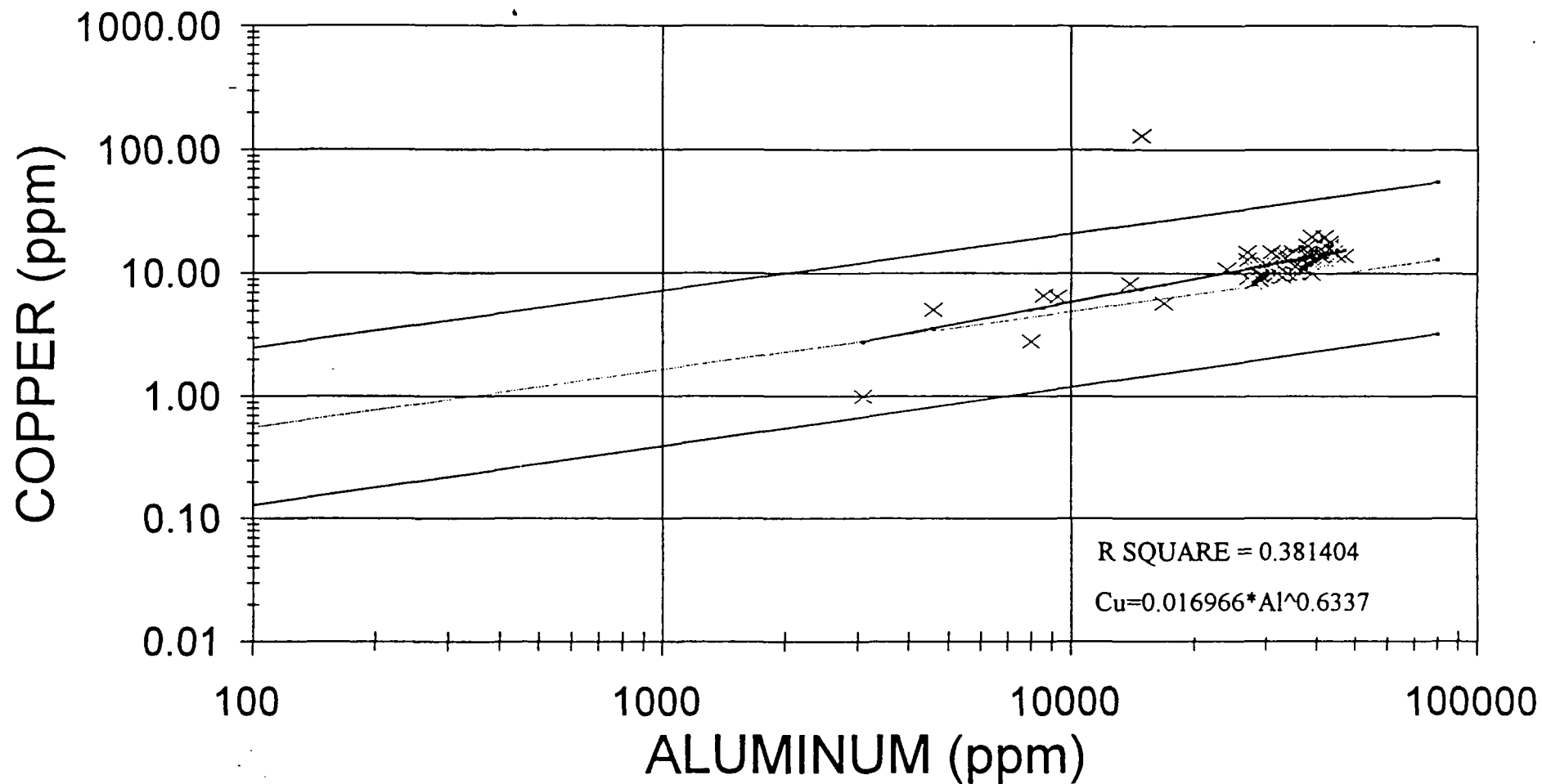


--- REGIONAL REGRESSION CURVE    — BRUNSWICK REGRESSION CURVE

GRAPH 5

# BRUNSWICK COMMUNITY STUDY 12/95

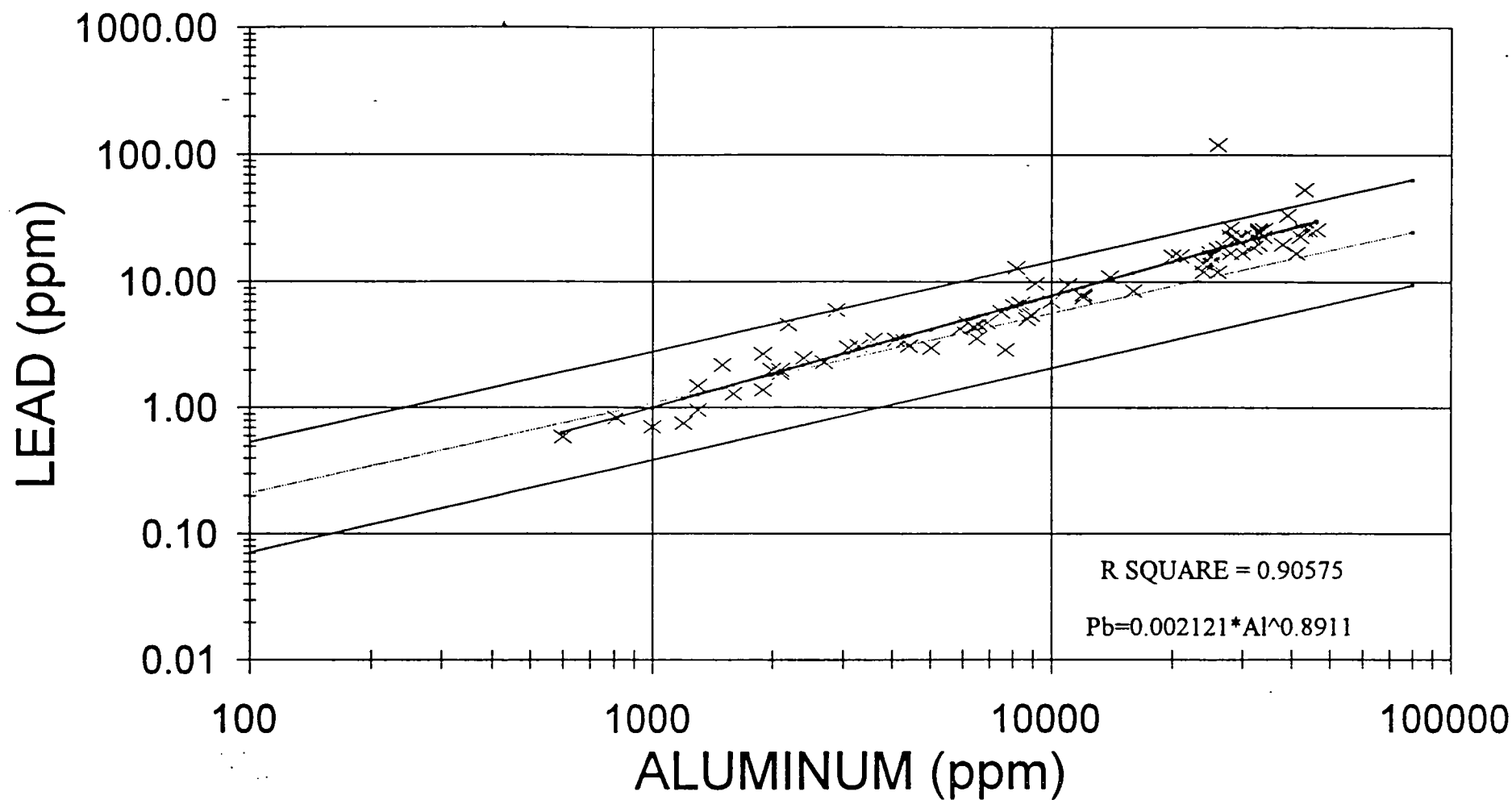
## MARSH SEDIMENT - COPPER / ALUMINUM



GRAPH 6

# BRUNSWICK COMMUNITY STUDY 12/95

## RIVER SEDIMENT - LEAD / ALUMINUM

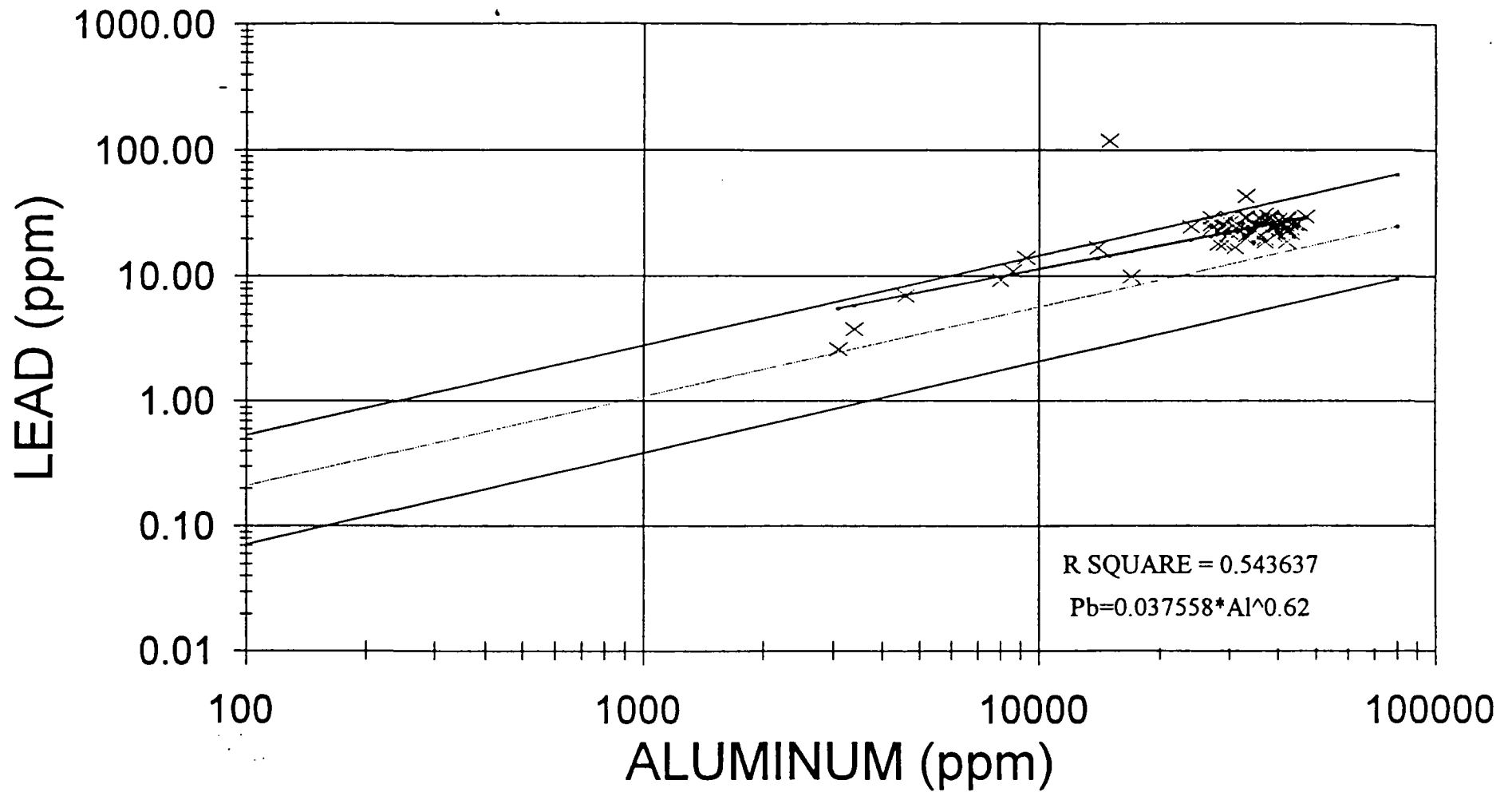


—•— REGIONAL REGRESSION CURVE    — BRUNSWICK REGRESSION CURVE

GRAPH 7

# BRUNSWICK COMMUNITY STUDY 12/95

## MARSH SEDIMENT - LEAD / ALUMINUM



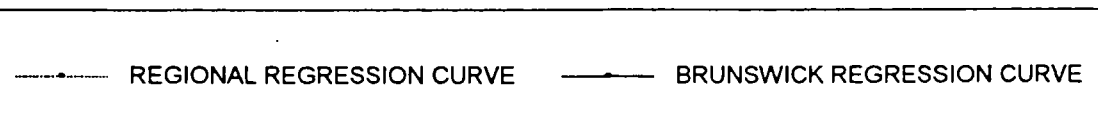
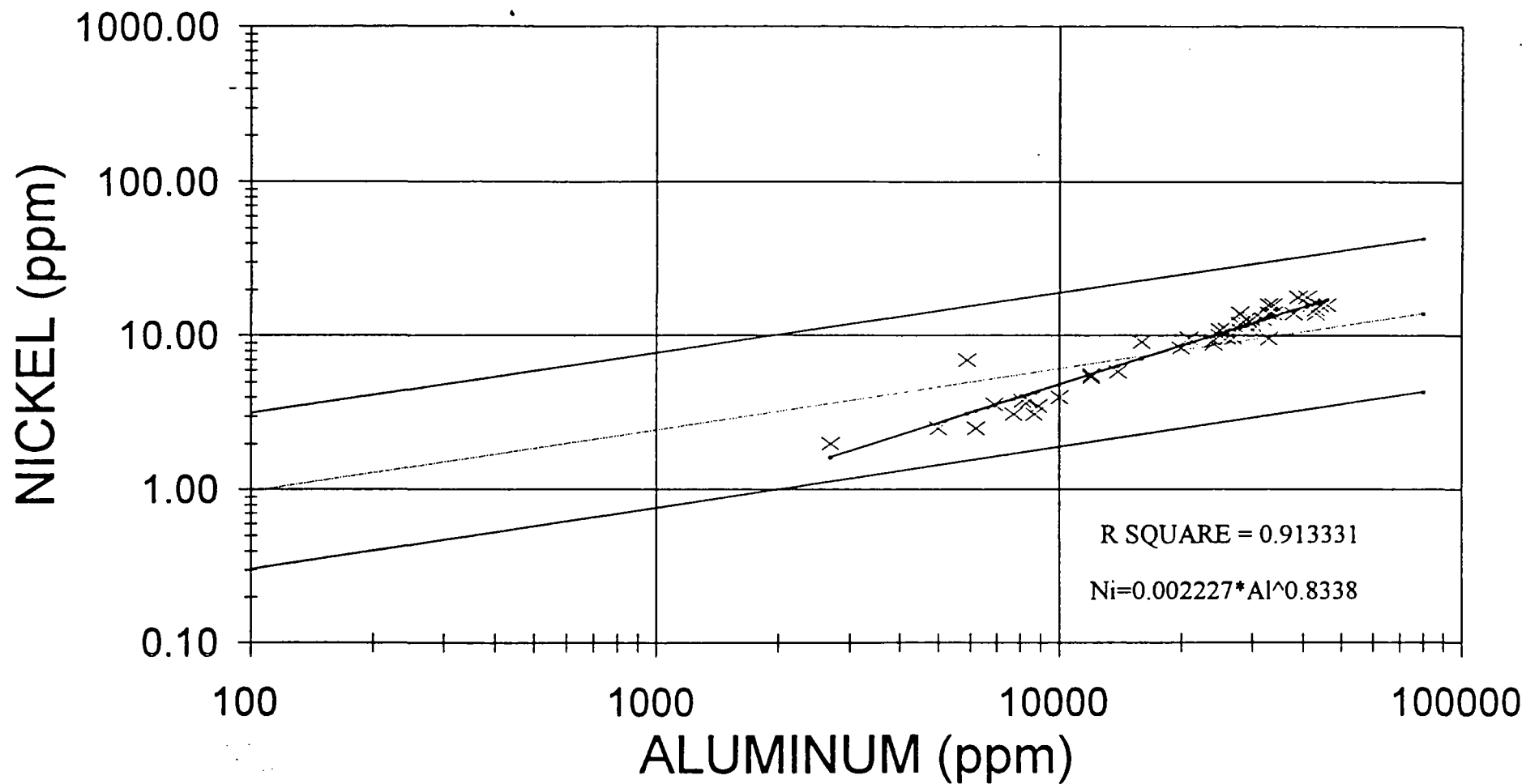
--- REGIONAL REGRESSION CURVE    — BRUNSWICK REGRESSION CURVE

GRAPH 8



# BRUNSWICK COMMUNITY STUDY 12/95

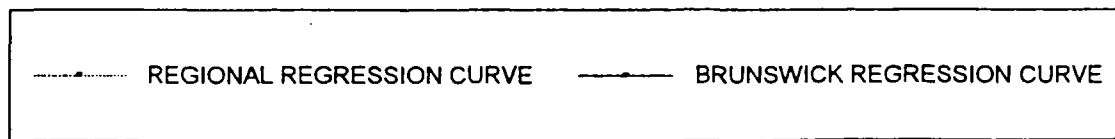
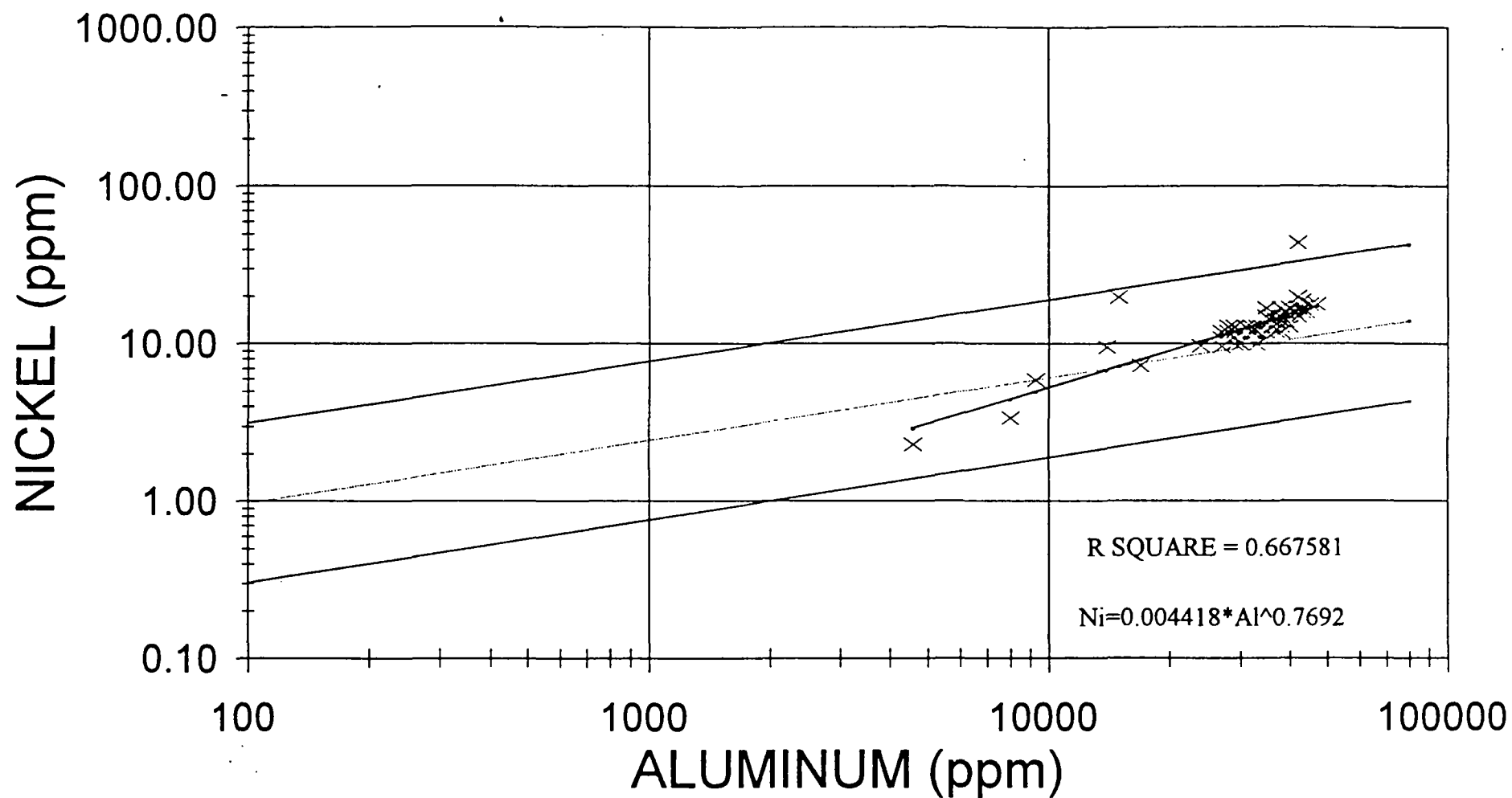
## RIVER SEDIMENT - NICKEL / ALUMINUM



GRAPH 9

# BRUNSWICK COMMUNITY STUDY 12/95

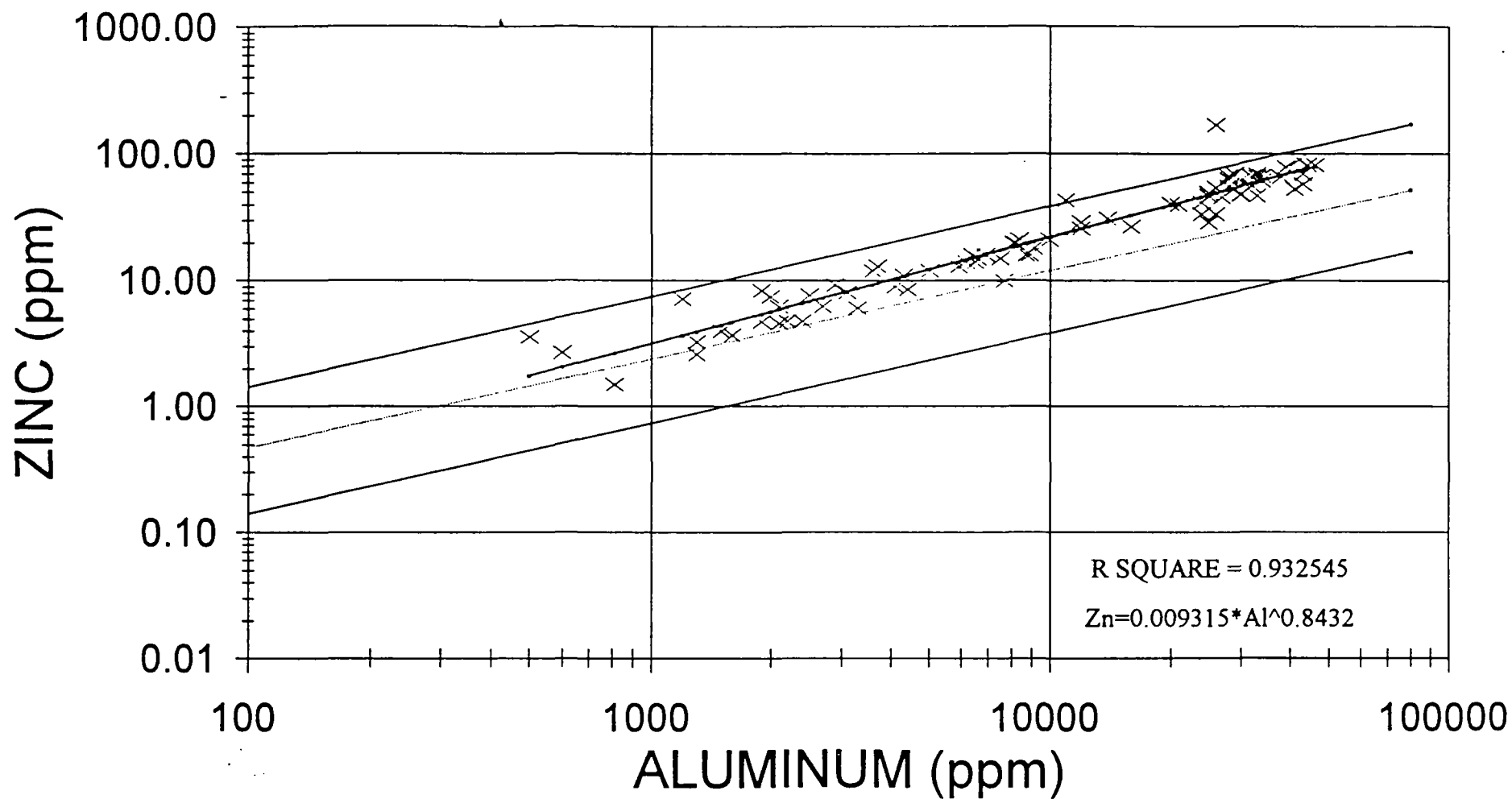
## MARSH SEDIMENT - NICKEL / ALUMINUM



GRAPH 10

# BRUNSWICK COMMUNITY STUDY 12/95

## RIVER SEDIMENT - ZINC / ALUMINUM

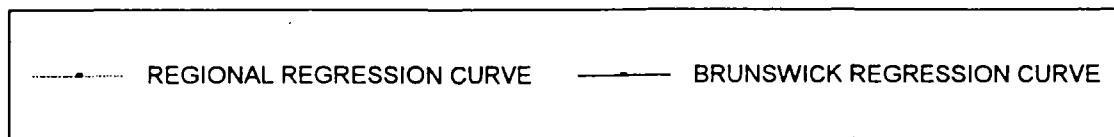
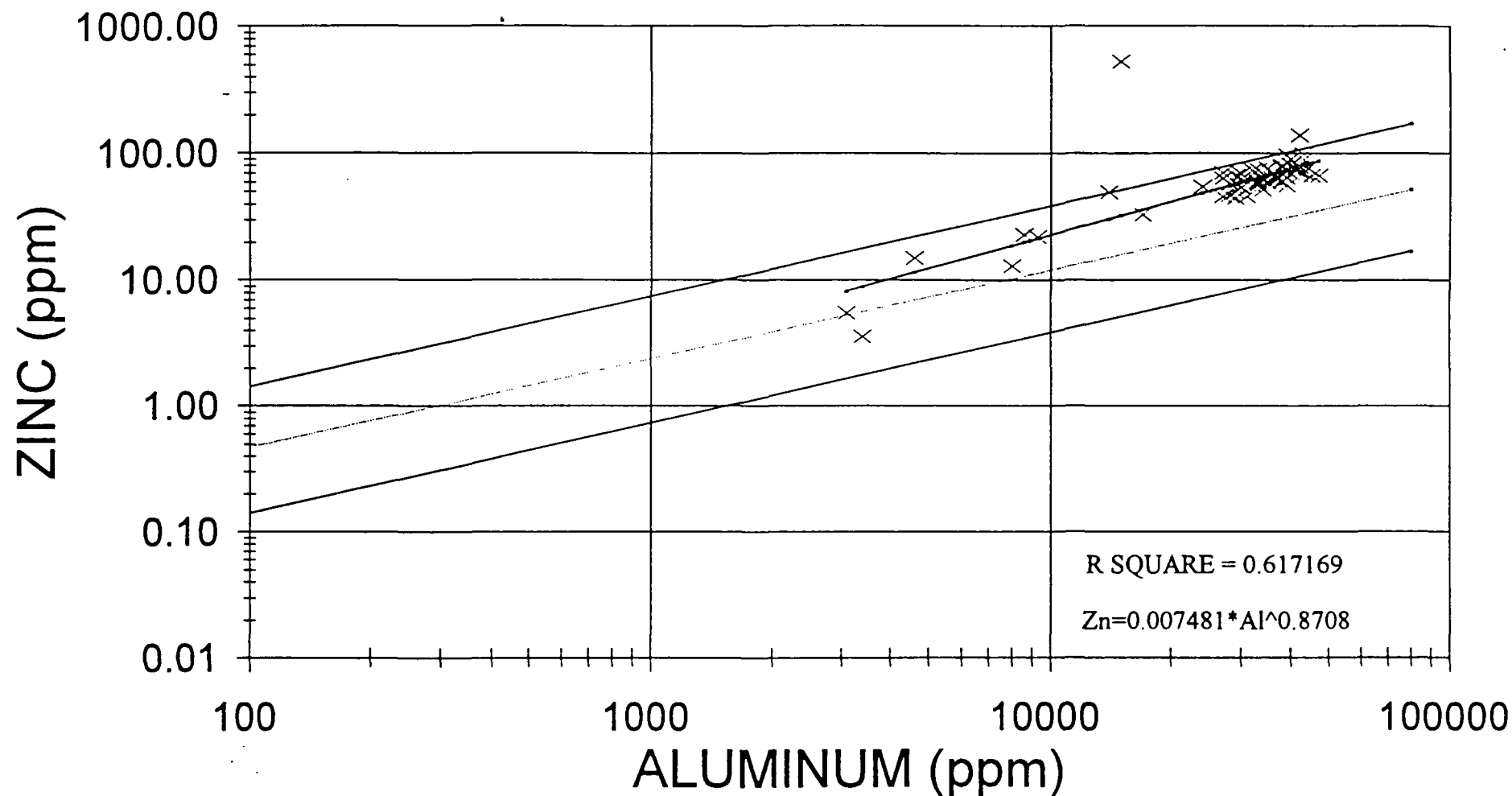


--- REGIONAL REGRESSION CURVE      — BRUNSWICK REGRESSION CURVE

GRAPH 11

# BRUNSWICK COMMUNITY STUDY 12/95

## MARSH SEDIMENT - ZINC / ALUMINUM

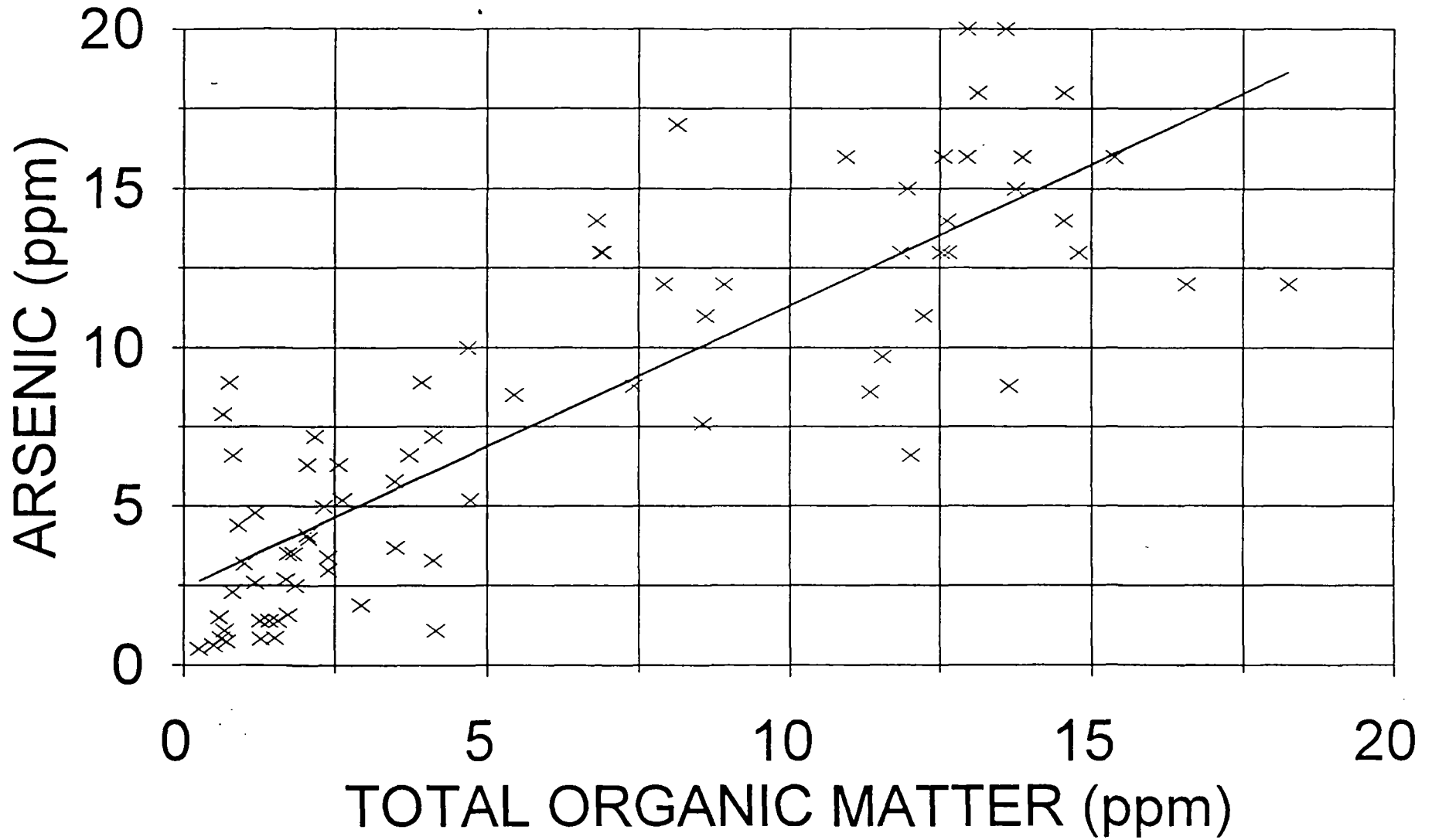


GRAPH 12

# BRUNSWICK COMMUNITY STUDY 12/95

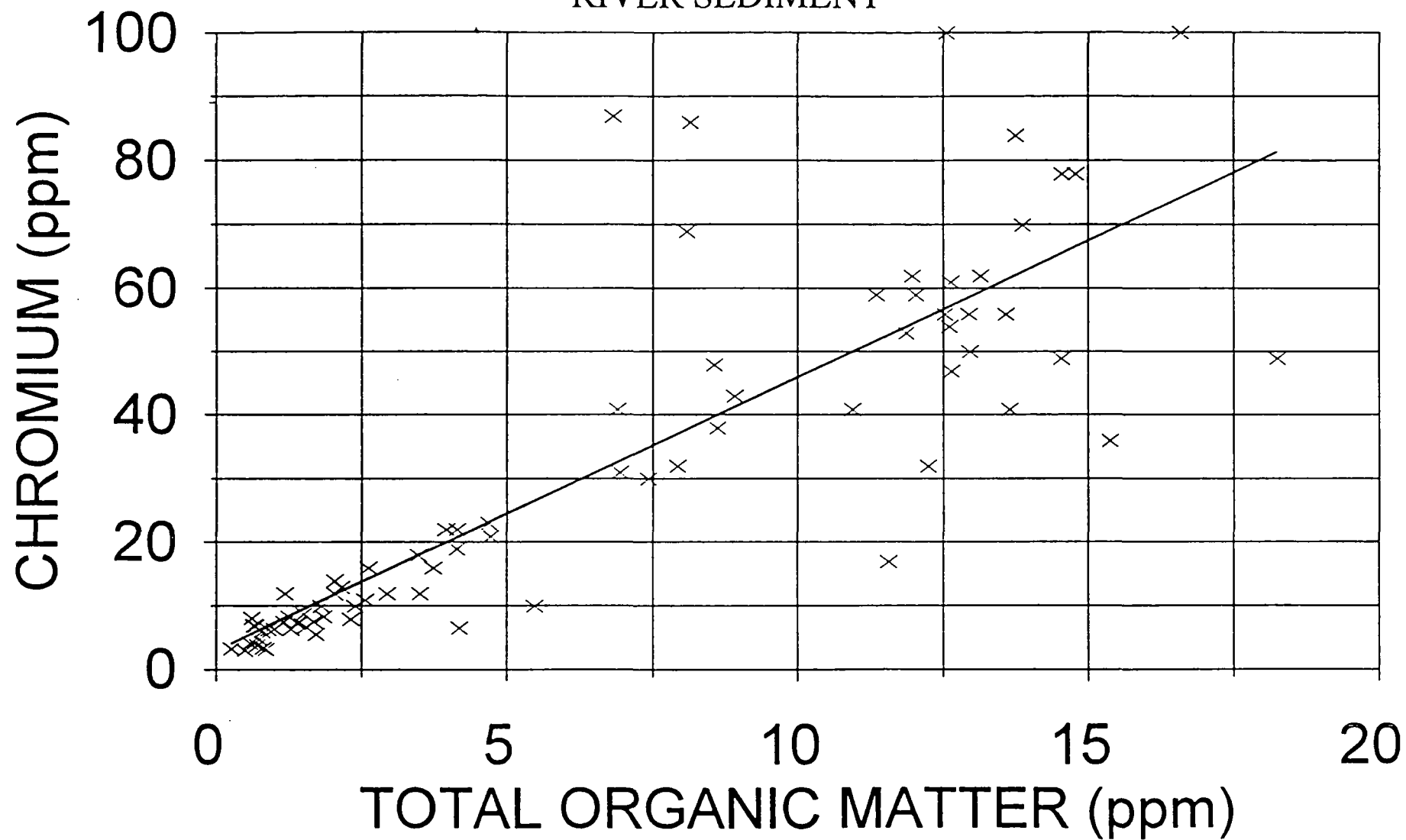
## ARSENIC vs TOTAL ORGANIC MATTER

### RIVER SEDIMENT



BRUNSWICK COMMUNITY STUDY 12/95  
CHROMIUM vs TOTAL ORGANIC MATTER

RIVER SEDIMENT

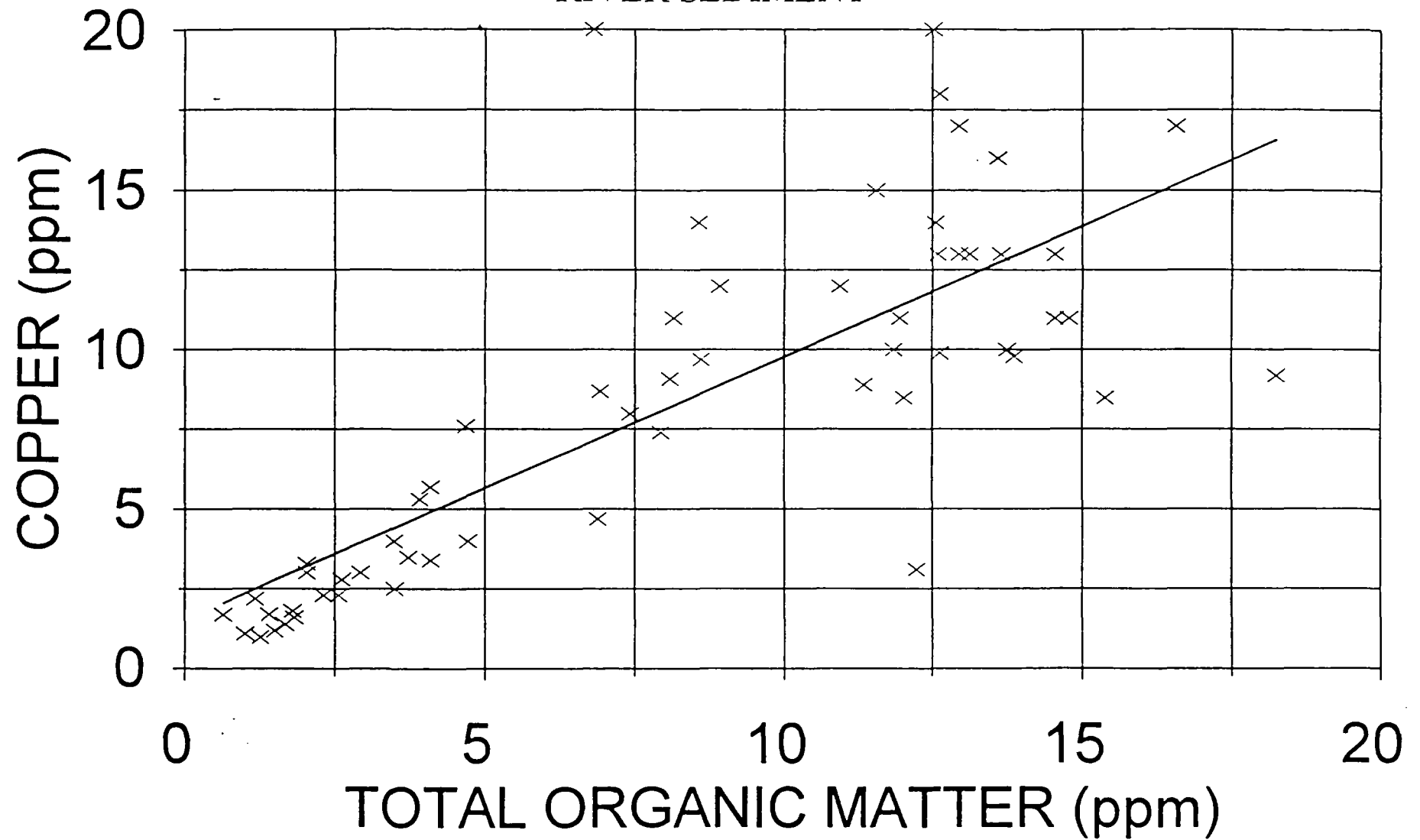


GRAPH 14

# BRUNSWICK COMMUNITY STUDY 12/95

## COPPER vs TOTAL ORGANIC MATTER

RIVER SEDIMENT

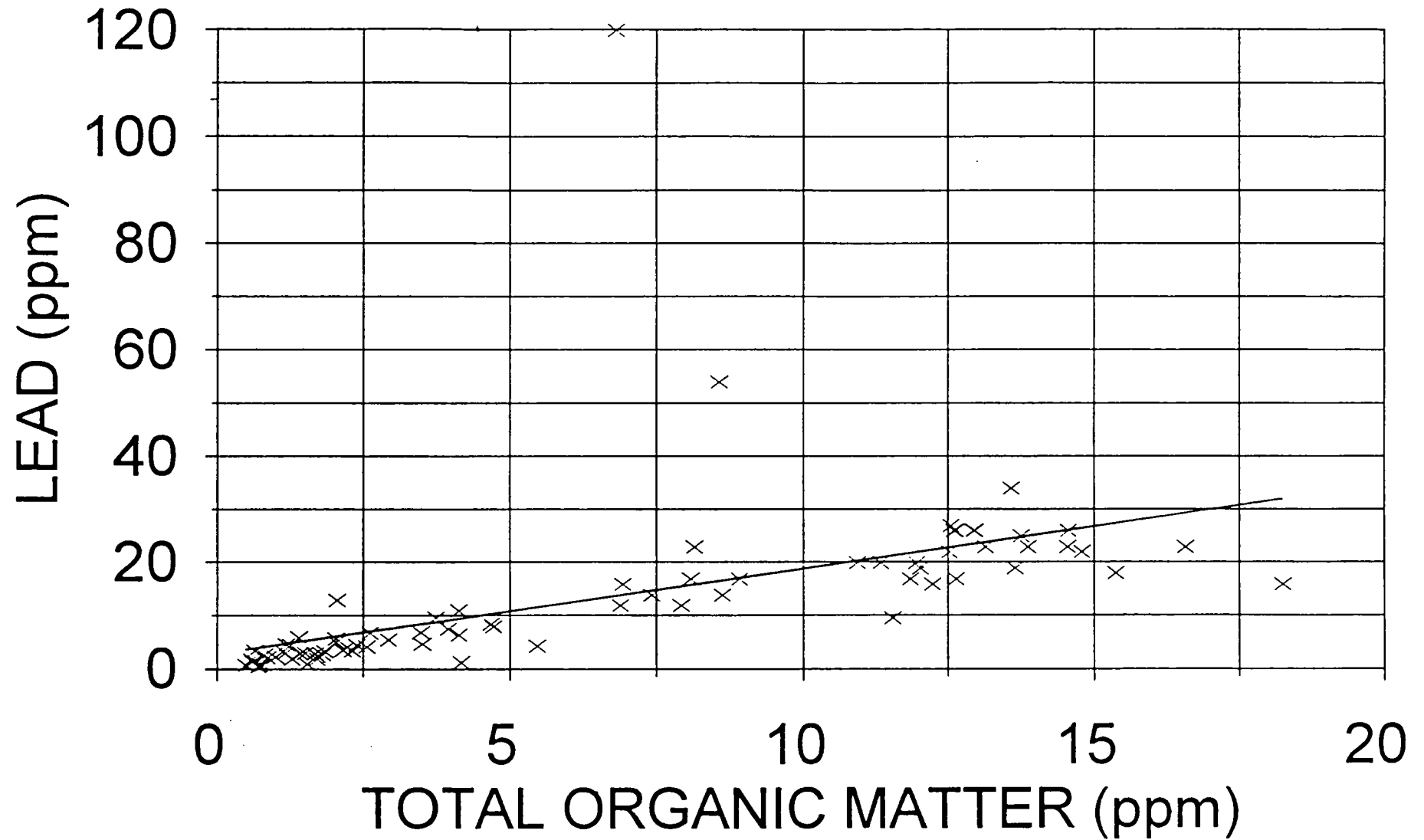


GRAPH 15

# BRUNSWICK COMMUNITY STUDY 12/95

## LEAD vs TOTAL ORGANIC MATTER

RIVER SEDIMENT

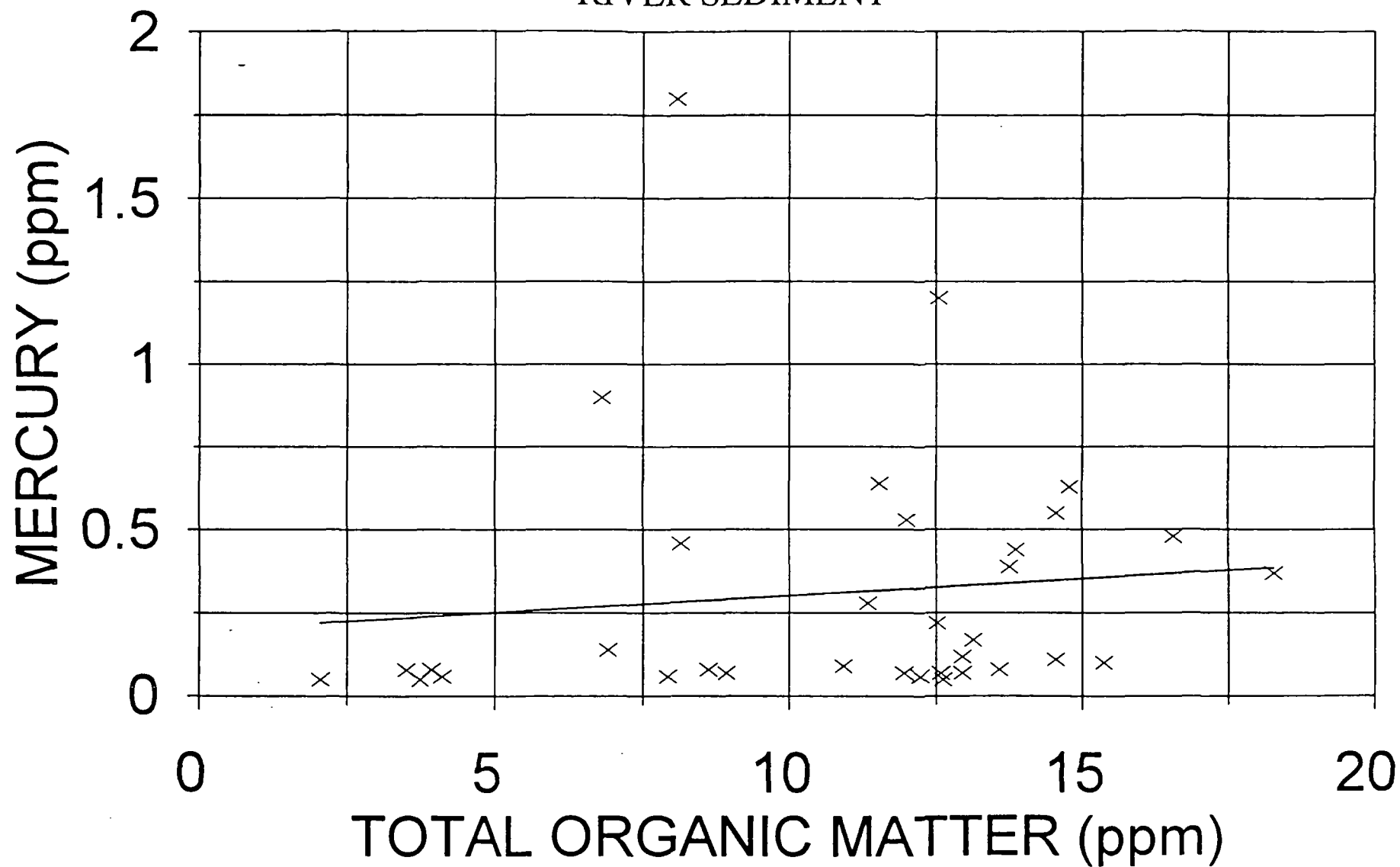


GRAPH 16



BRUNSWICK COMMUNITY STUDY 12/95  
MERCURY vs TOTAL ORGANIC MATTER

RIVER SEDIMENT

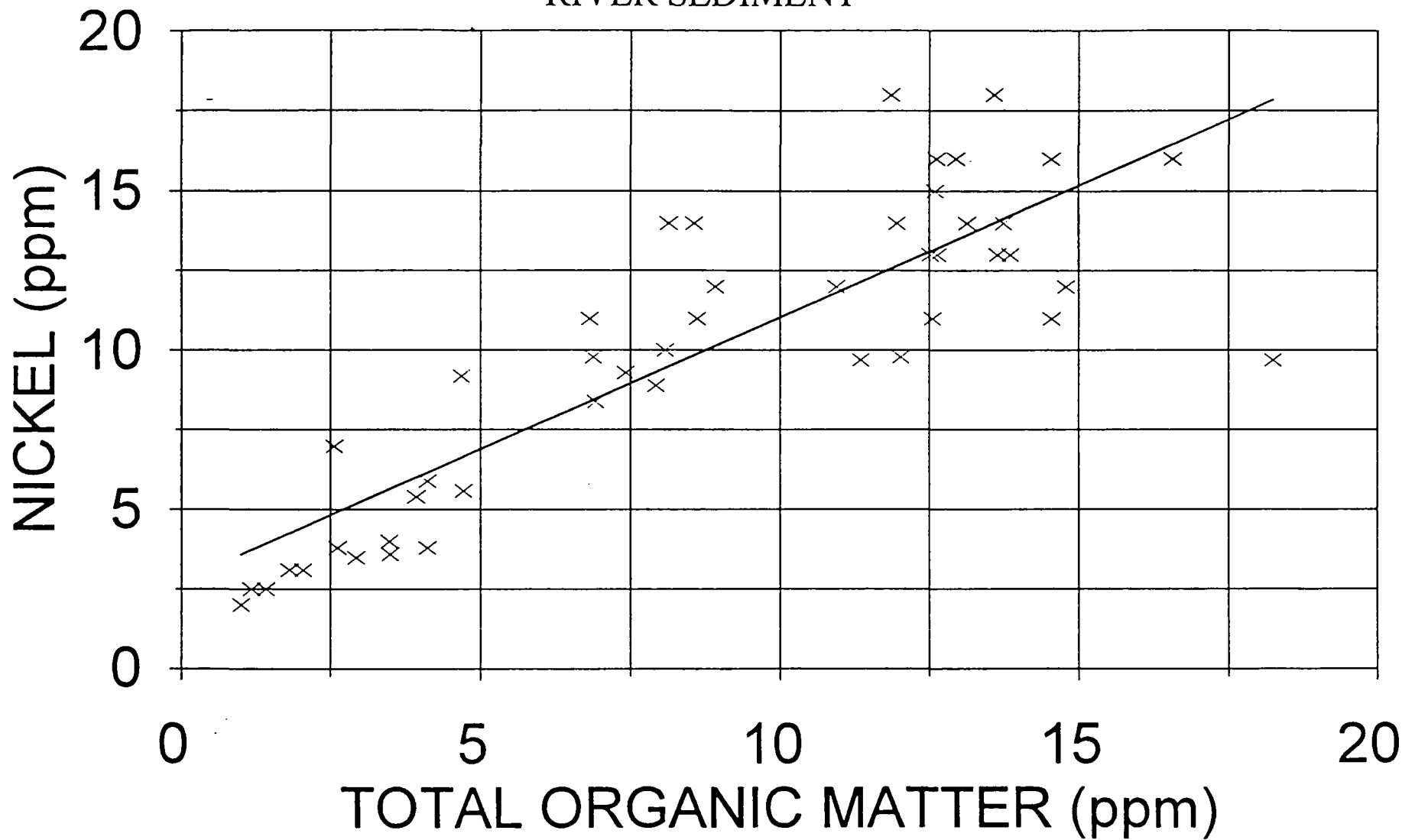


GRAPH 17

# BRUNSWICK COMMUNITY STUDY 12/95

## NICKEL vs TOTAL ORGANIC MATTER

RIVER SEDIMENT

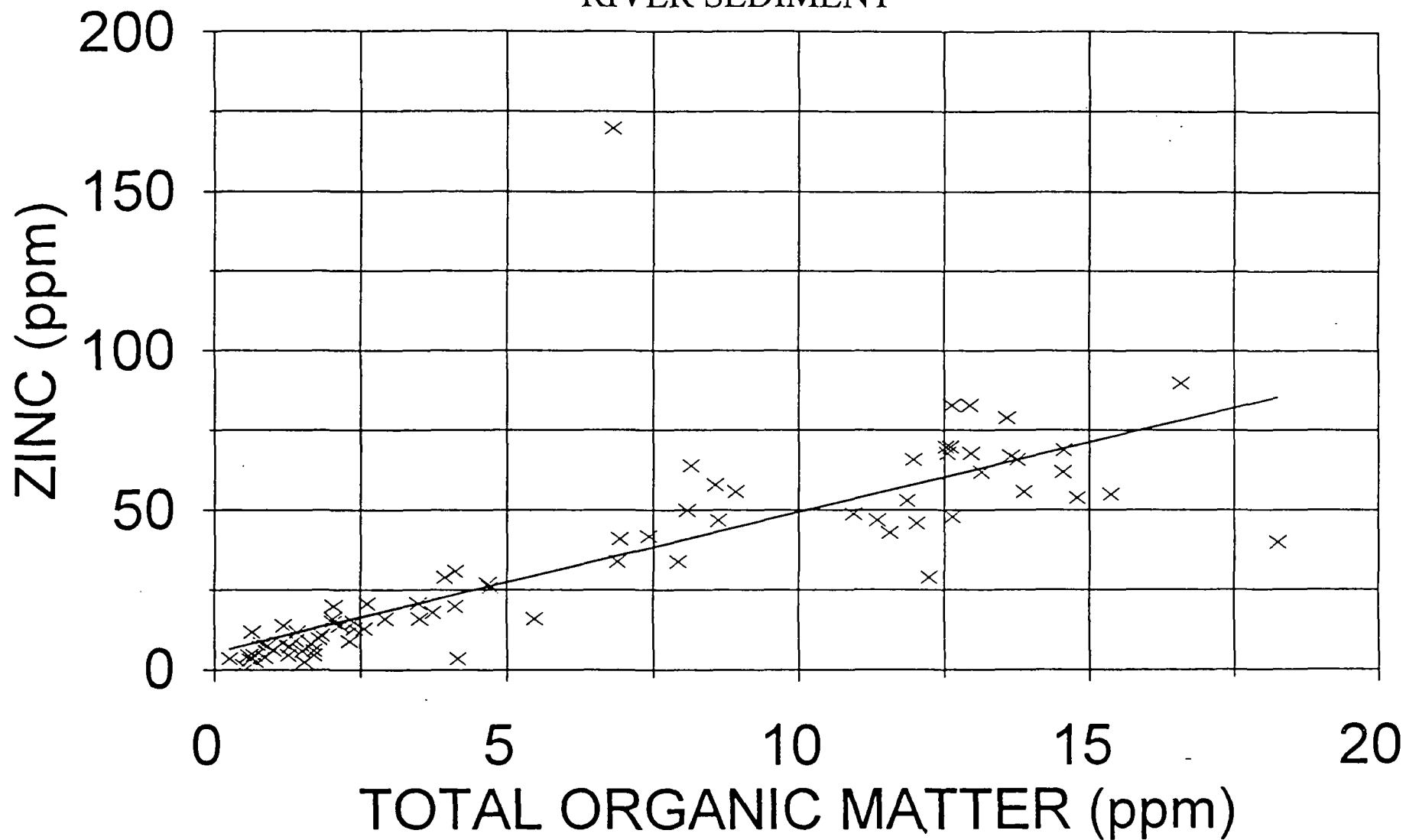


GRAPH 18

# BRUNSWICK COMMUNITY STUDY 12/95

## ZINC vs TOTAL ORGANIC MATTER

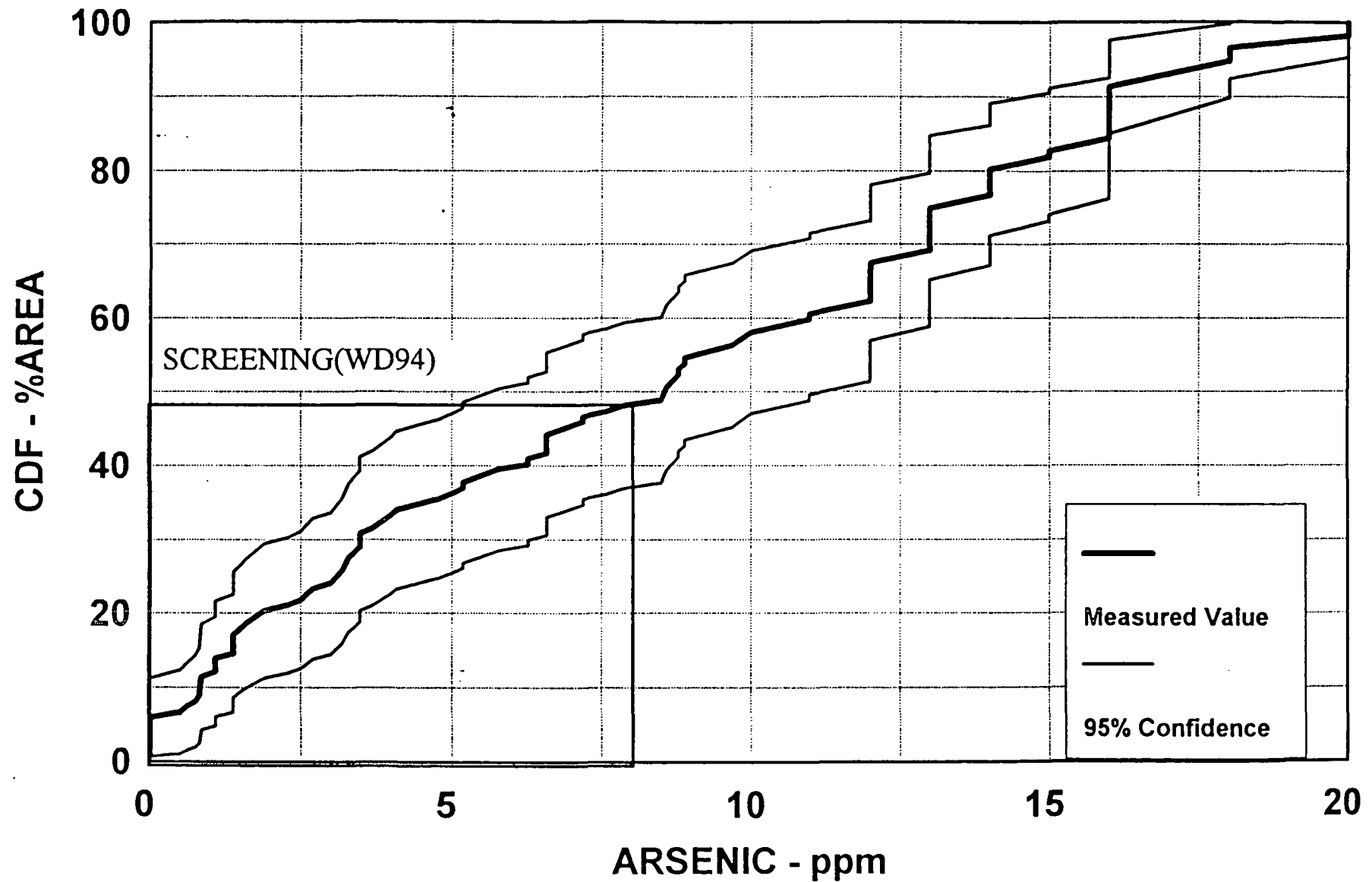
RIVER SEDIMENT



GRAPH 19

# BRUNSWICK COMMUNITY STUDY 12/95

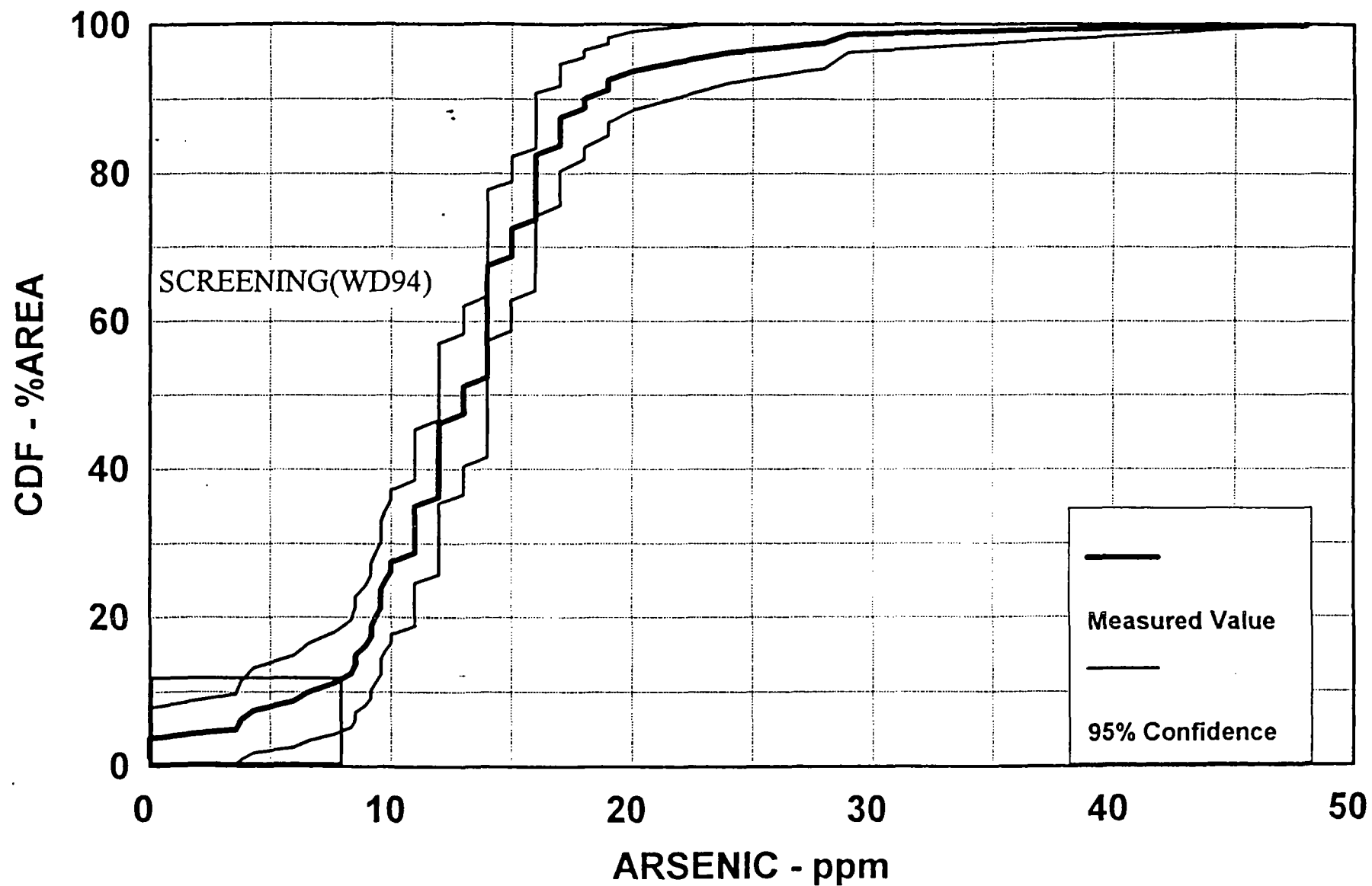
## ARSENIC IN RIVER SEDIMENT



GRAPH 20

# BRUNSWICK COMMUNITY STUDY 12/95

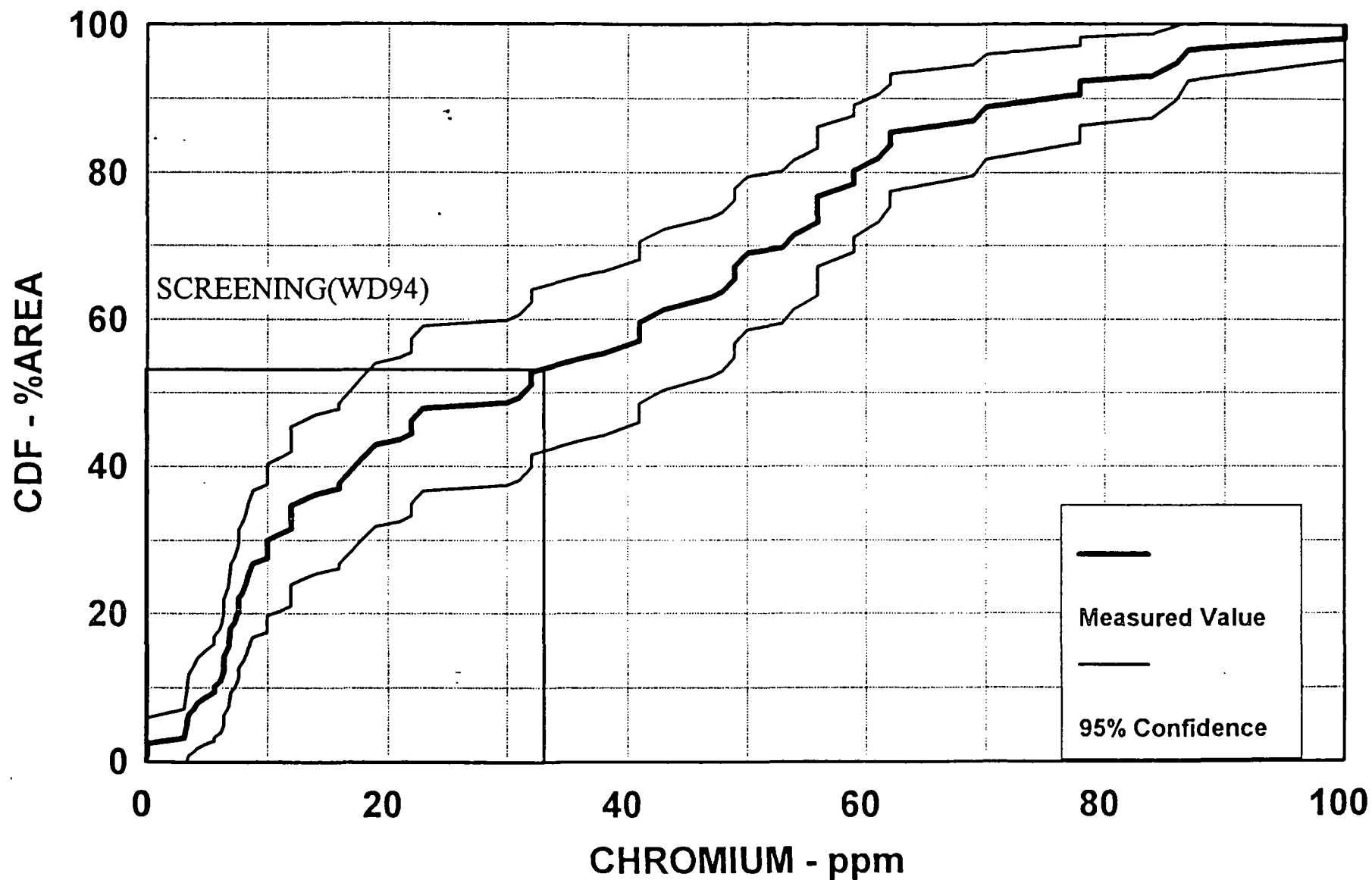
## ARSENIC IN MARSH SEDIMENT



GRAPH 21

# BRUNSWICK COMMUNITY STUDY 12/95

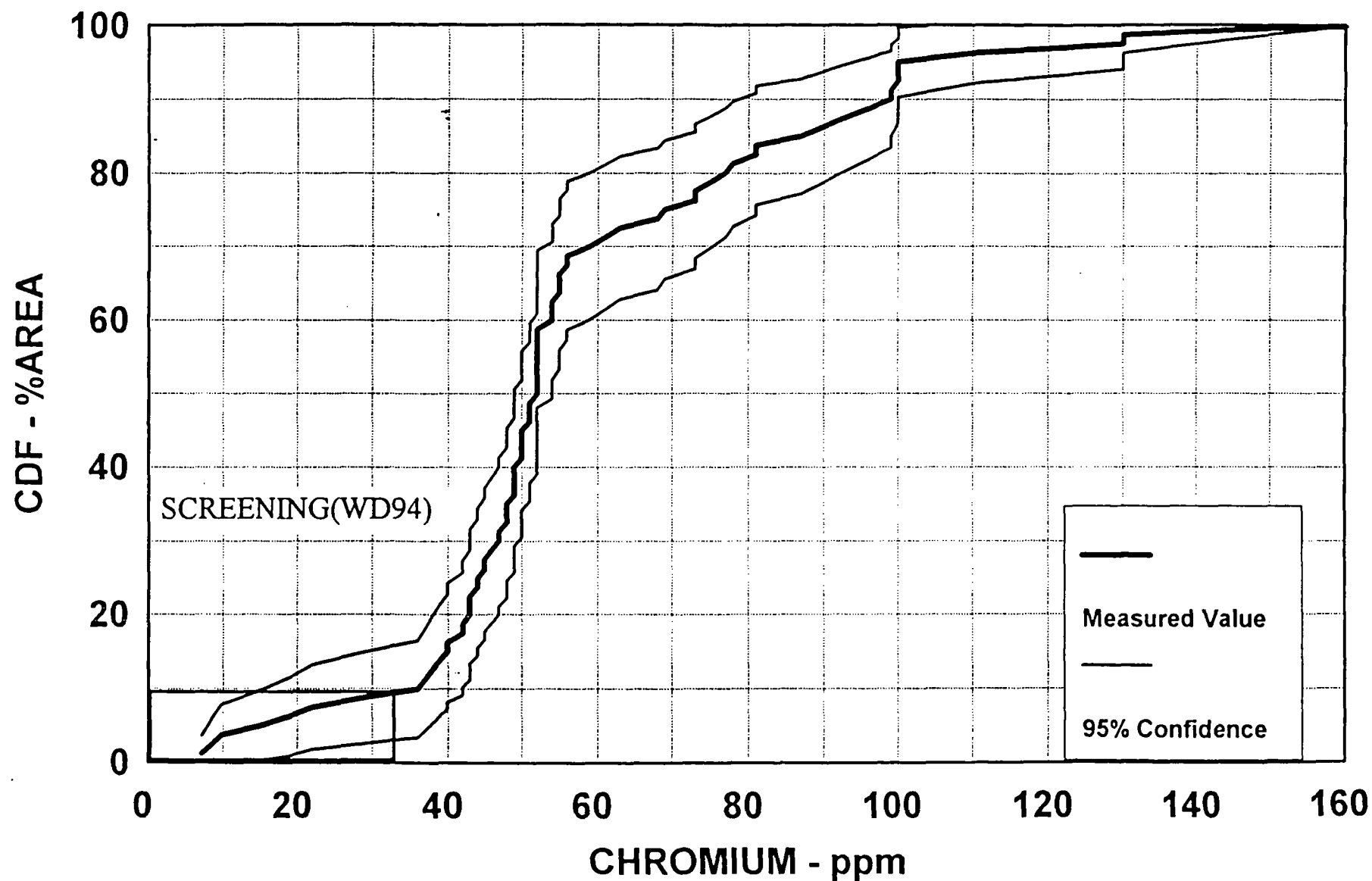
## CHROMIUM IN RIVER SEDIMENT



GRAPH 22

# BRUNSWICK COMMUNITY STUDY 12/95

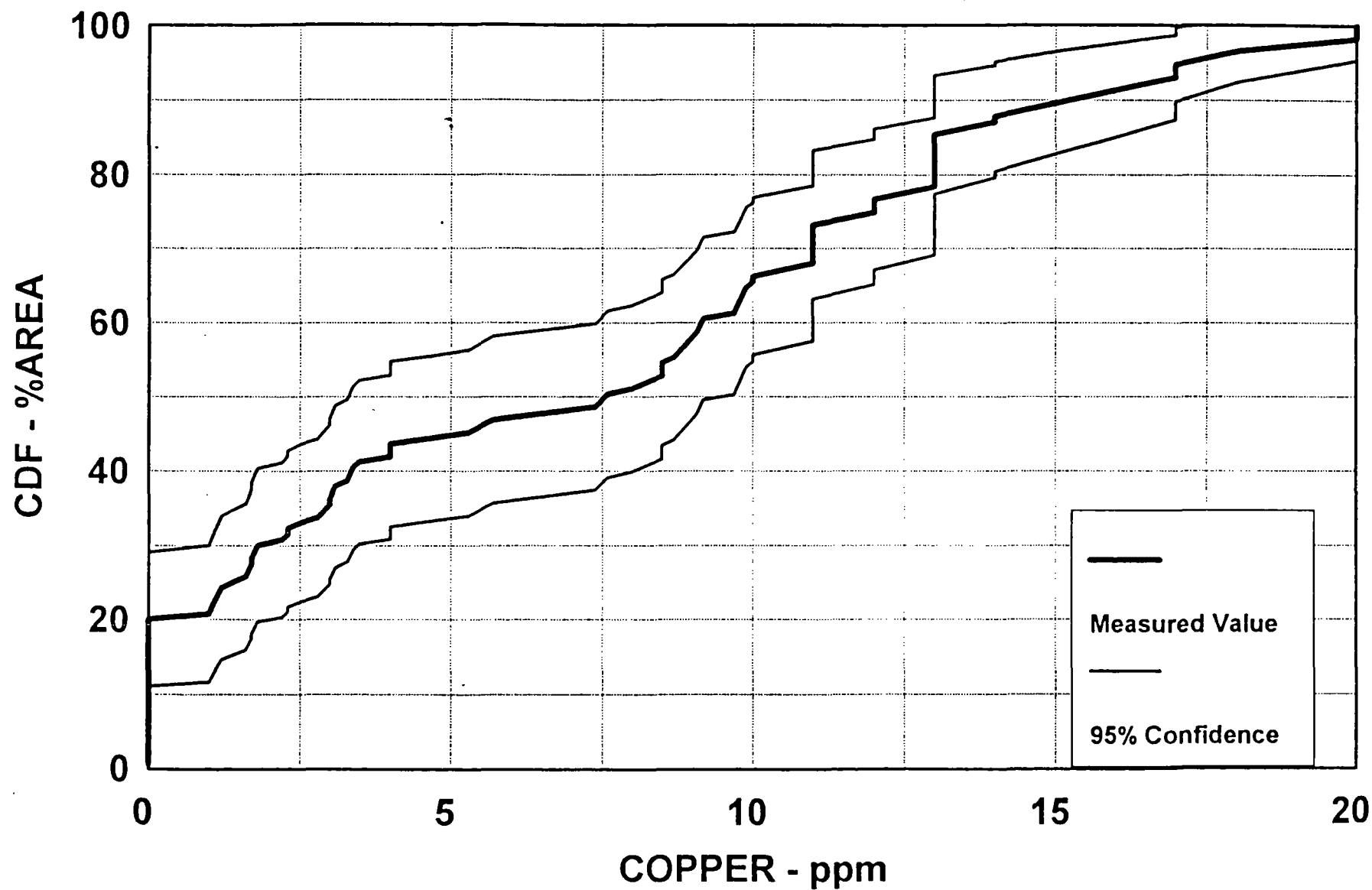
## CHROMIUM IN MARSH SEDIMENT



GRAPH 23

# BRUNSWICK COMMUNITY STUDY 12/95

## COPPER IN RIVER SEDIMENT

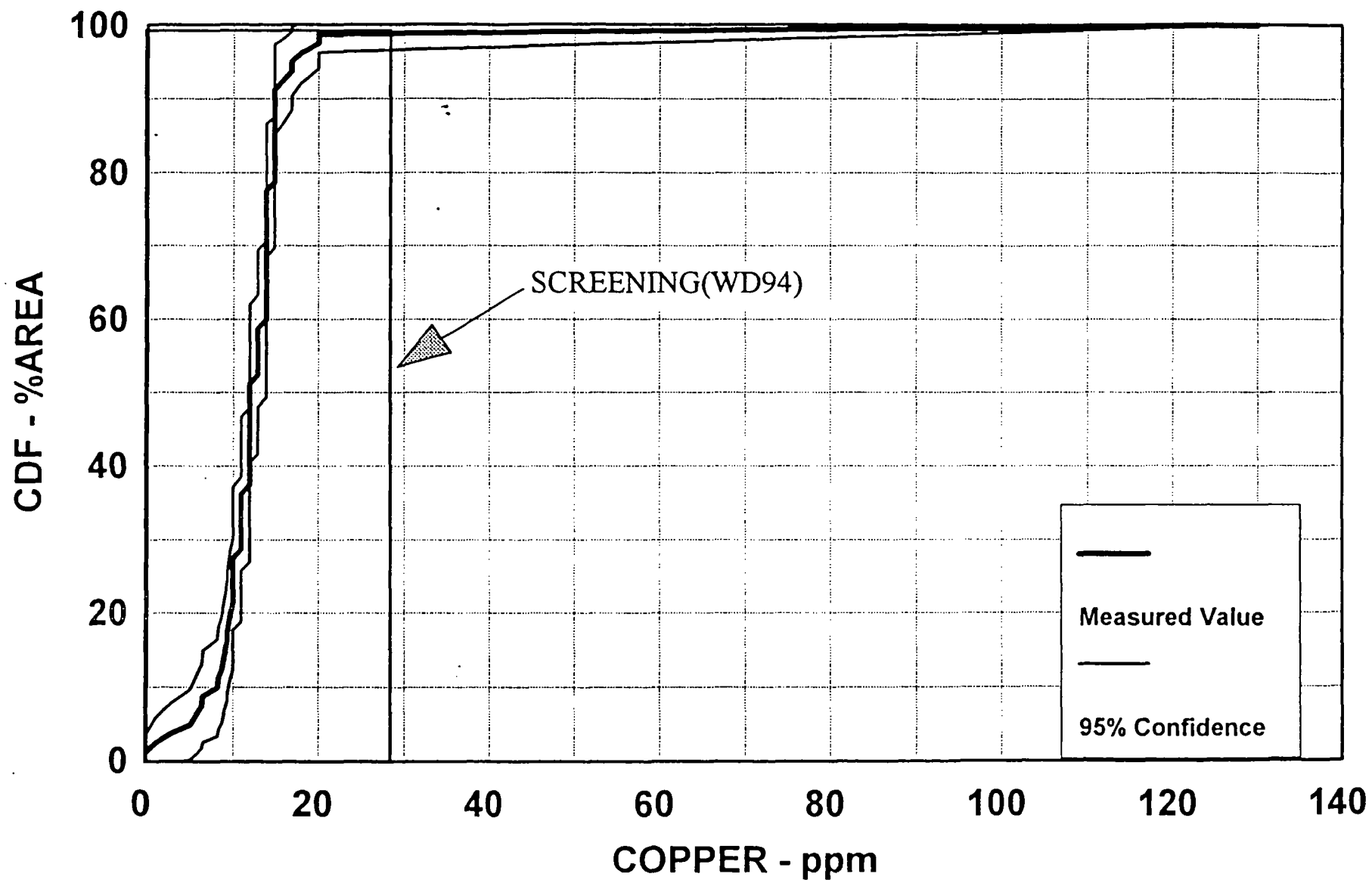


GRAPH 24



# BRUNSWICK COMMUNITY STUDY 12/95

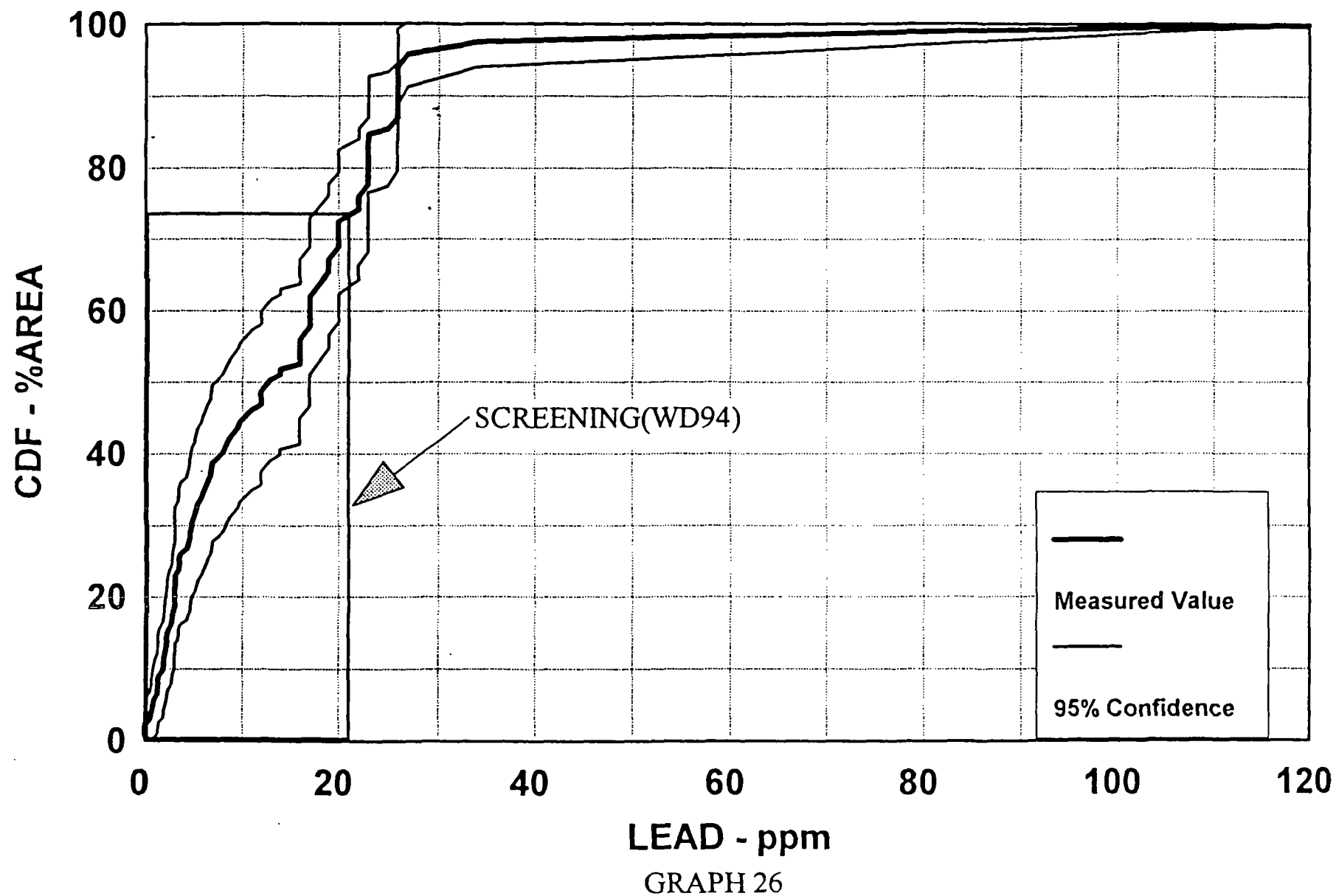
## COPPER IN MARSH SEDIMENT



GRAPH 25

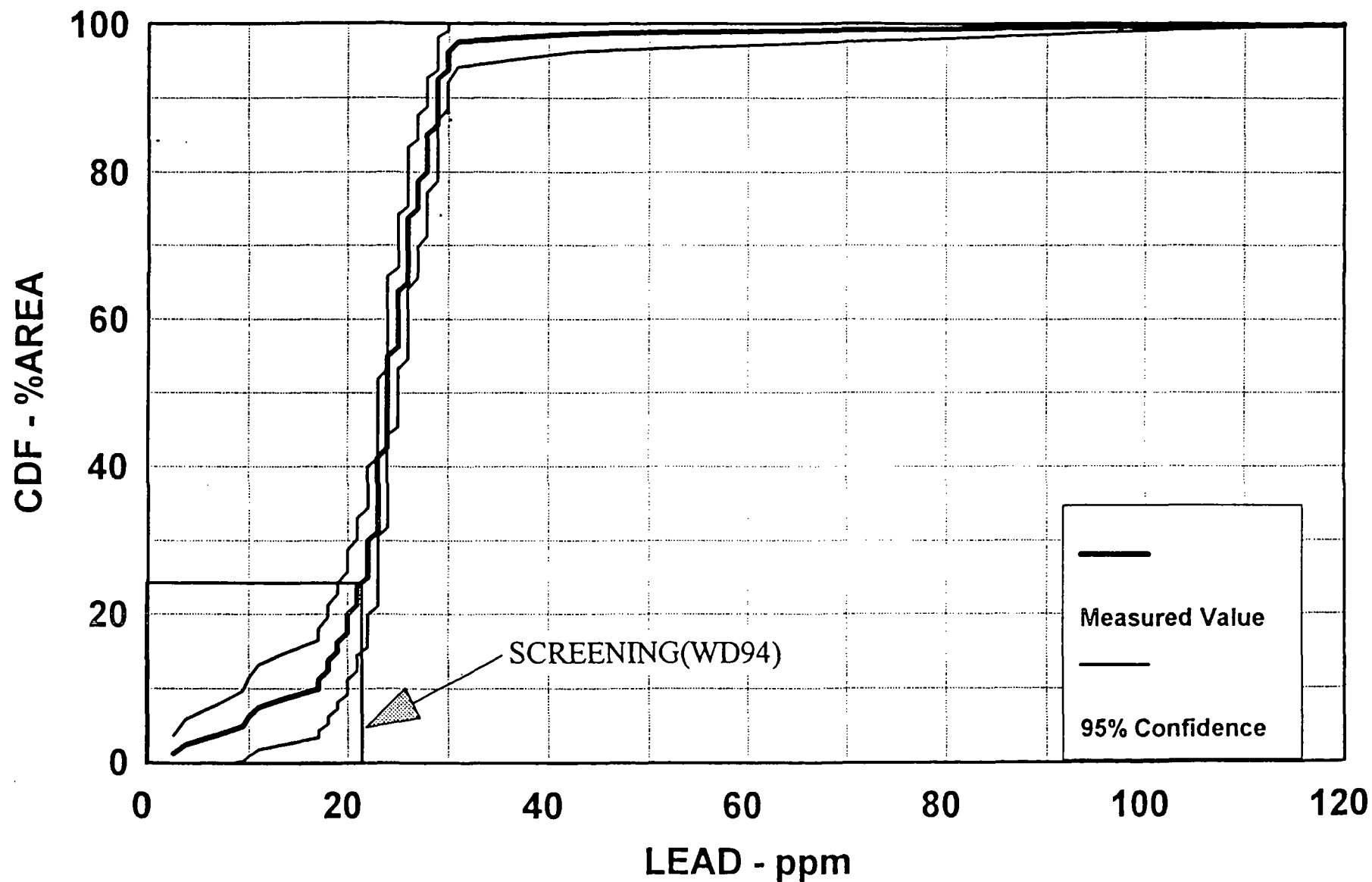
# BRUNSWICK COMMUNITY STUDY 12/95

## LEAD IN RIVER SEDIMENT



# BRUNSWICK COMMUNITY STUDY 12/95

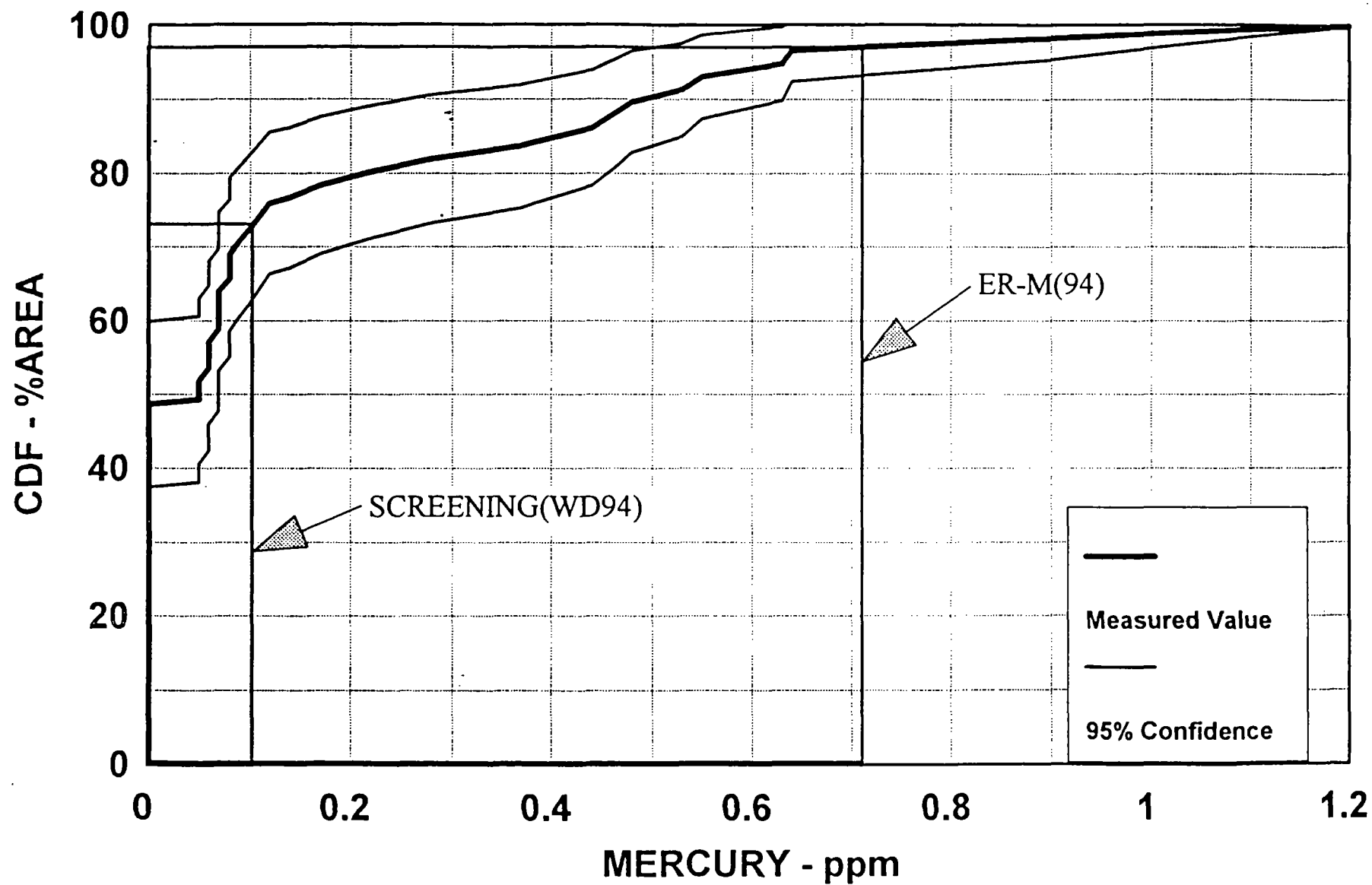
## LEAD IN MARSH SEDIMENT



GRAPH 27

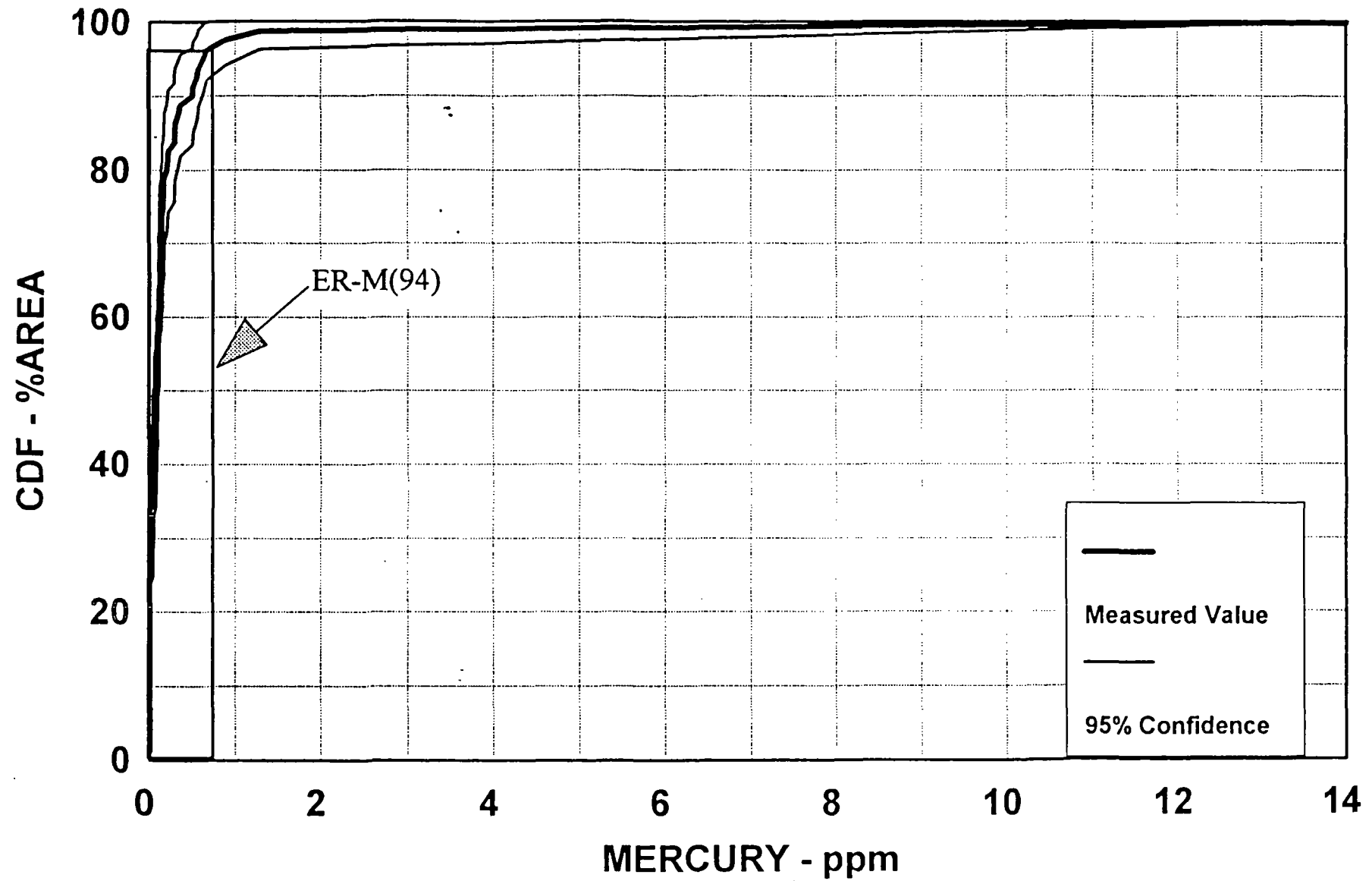
# BRUNSWICK COMMUNITY STUDY 12/95

## MERCURY IN RIVER SEDIMENT



GRAPH 28

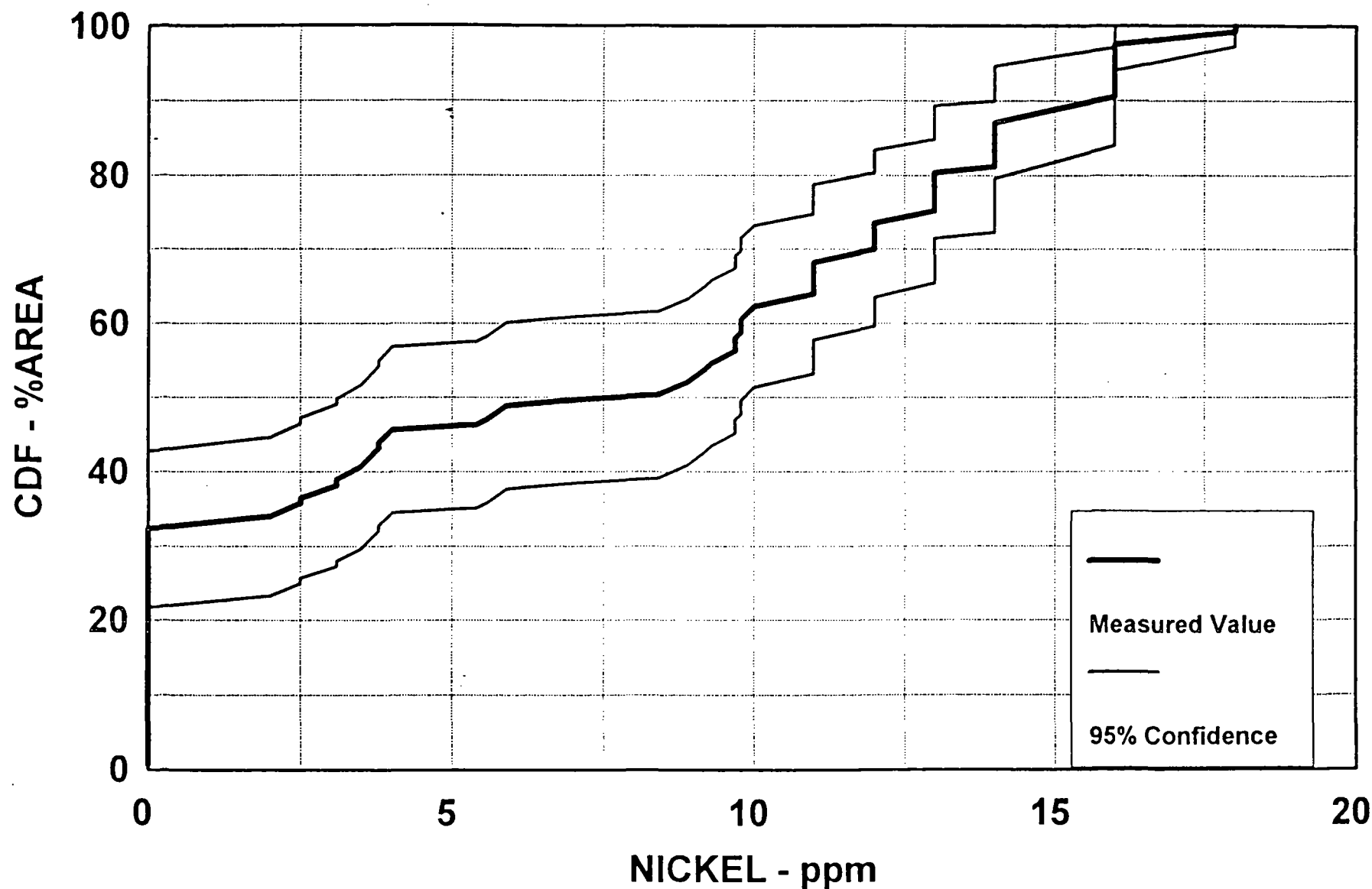
# BRUNSWICK COMMUNITY STUDY MERCURY IN MARSH SEDIMENT



GRAPH 29

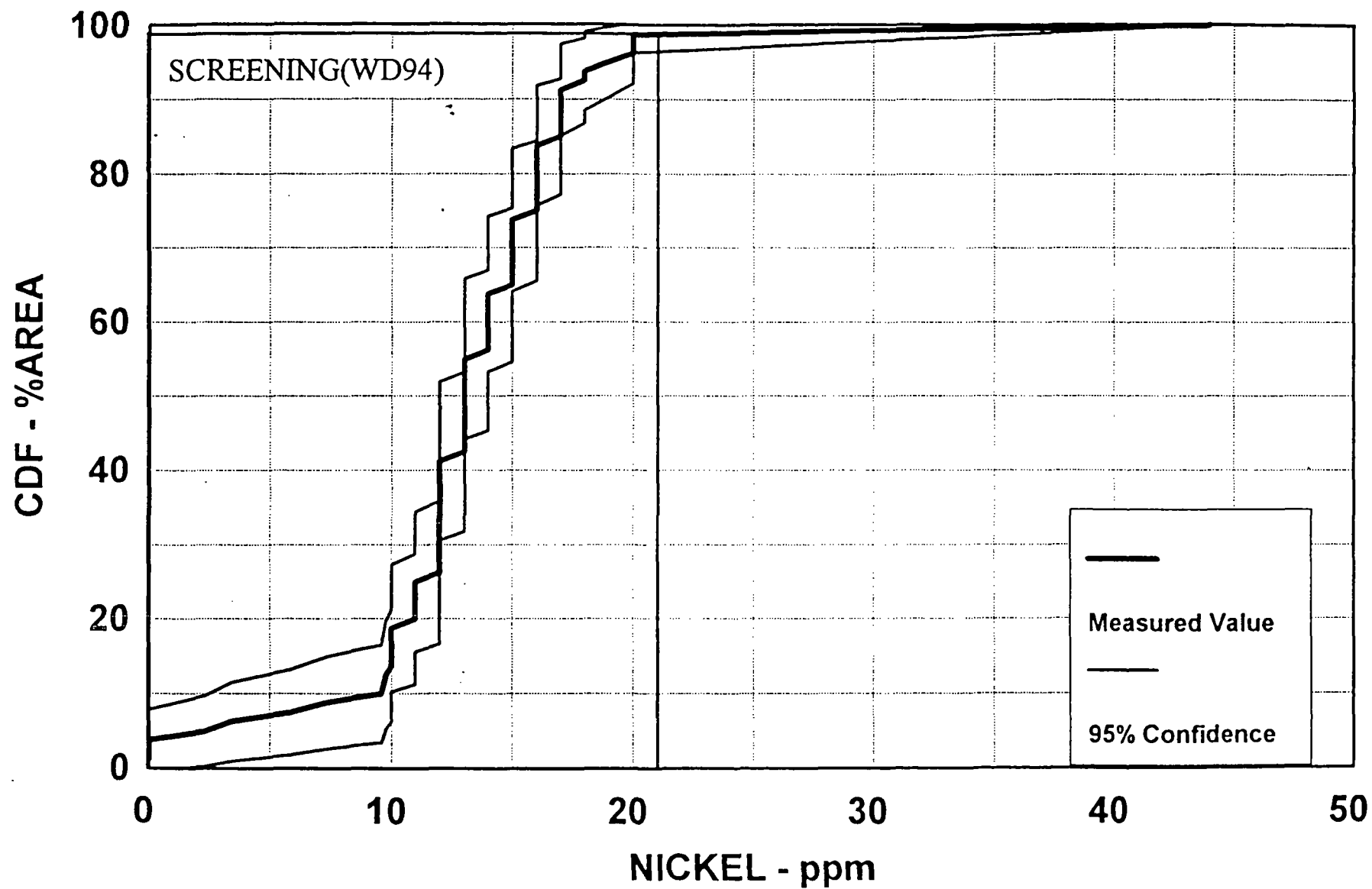
# BRUNSWICK COMMUNITY STUDY 12/95

## NICKEL IN RIVER SEDIMENT



GRAPH 30

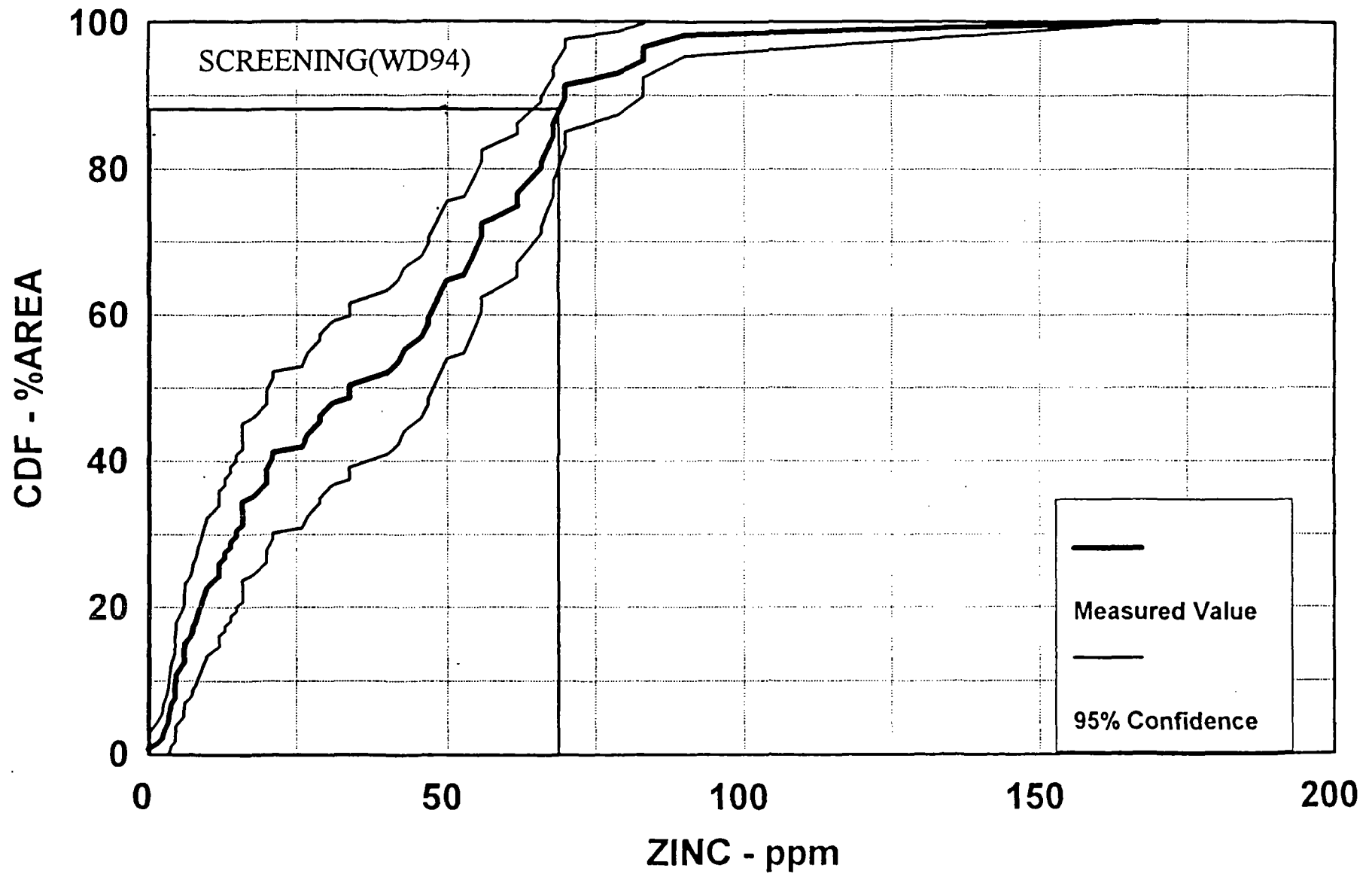
# BRUNSWICK COMMUNITY STUDY NICKEL IN MARSH SEDIMENT



GRAPH 31

# BRUNSWICK COMMUNITY STUDY 12/95

## ZINC IN RIVER SEDIMENT

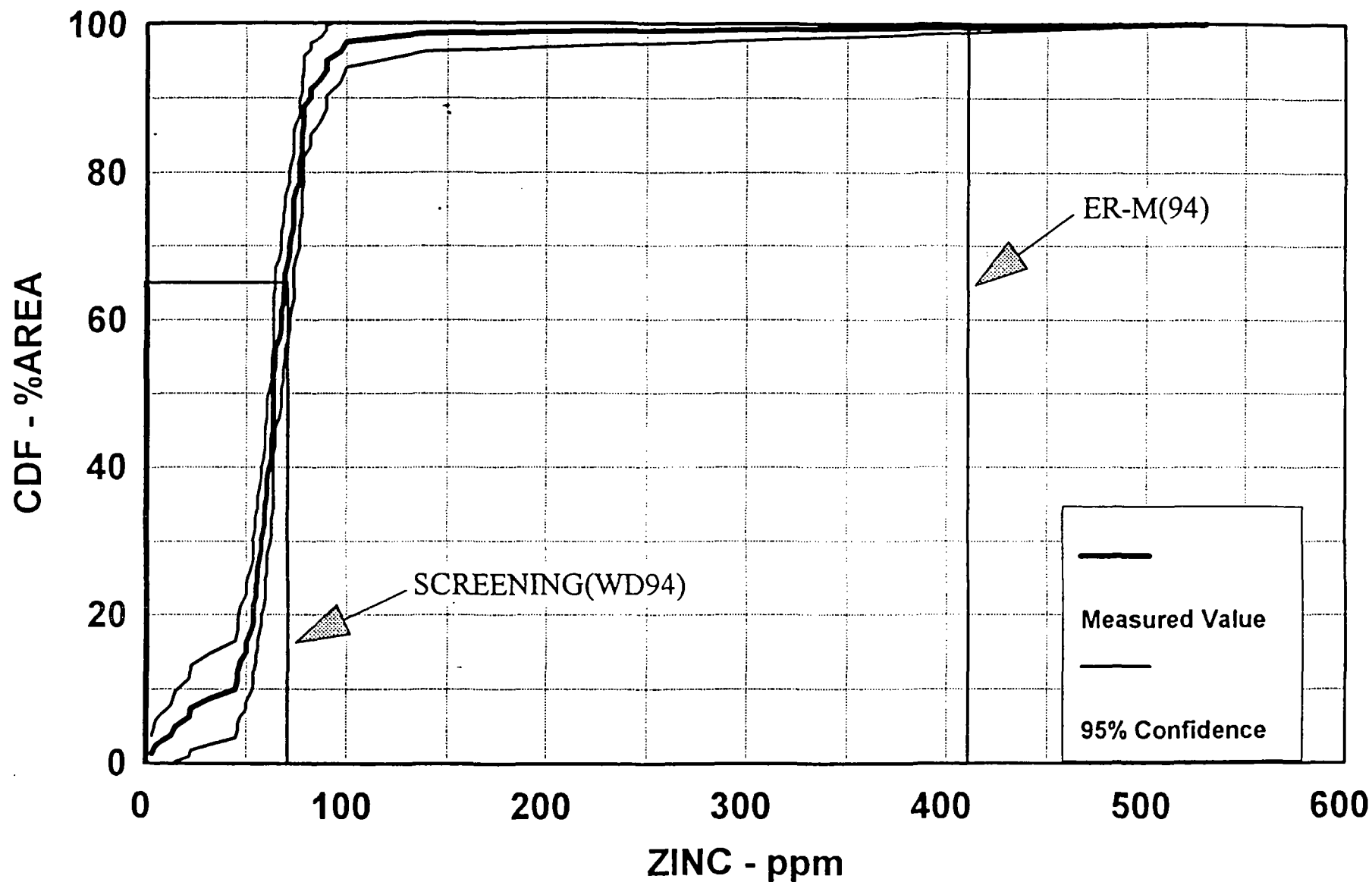


GRAPH 32



# BRUNSWICK COMMUNITY STUDY 12/95

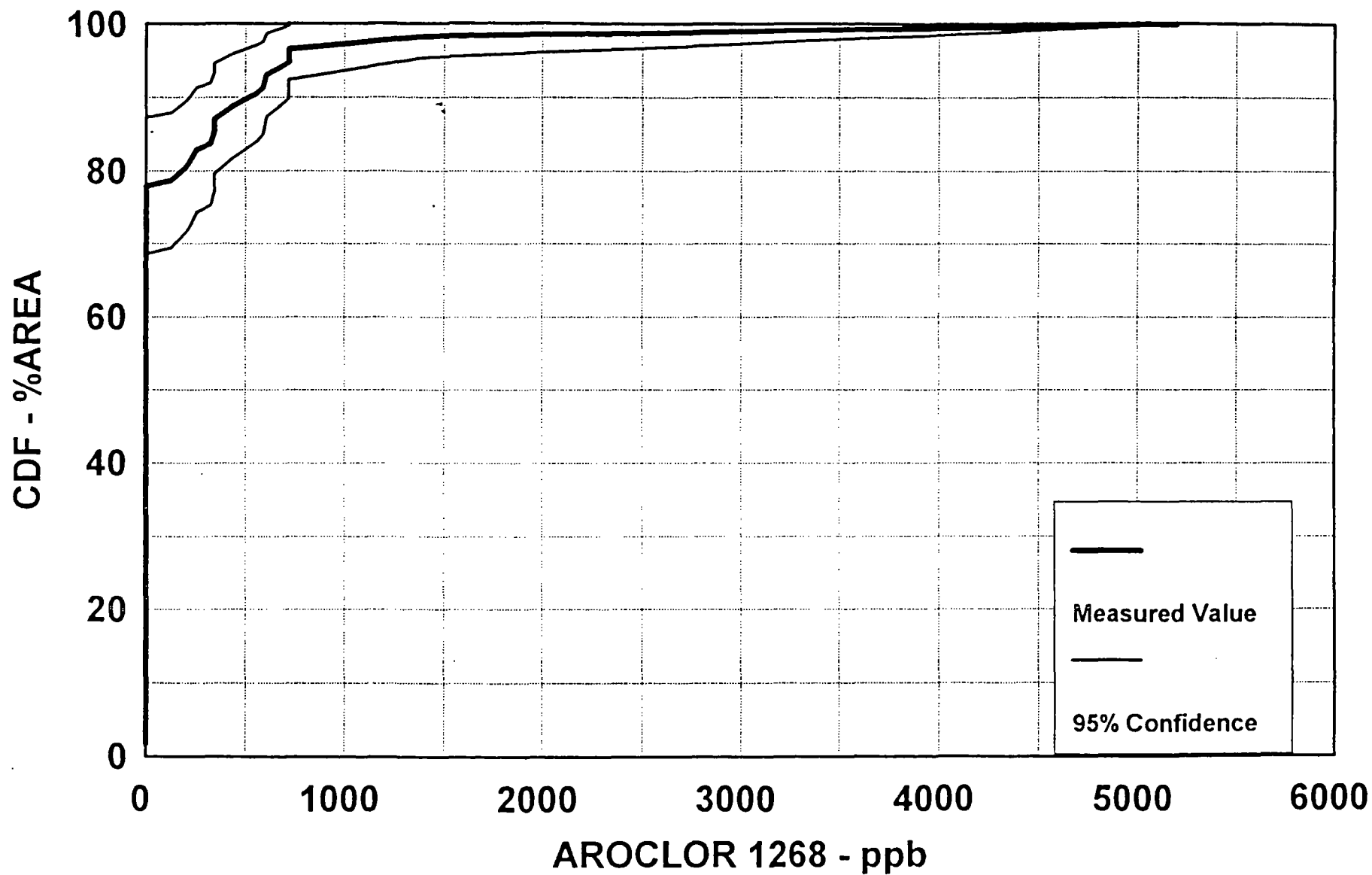
## ZINC IN MARSH SEDIMENT



GRAPH 33

# BRUNSWICK COMMUNITY STUDY 12/95

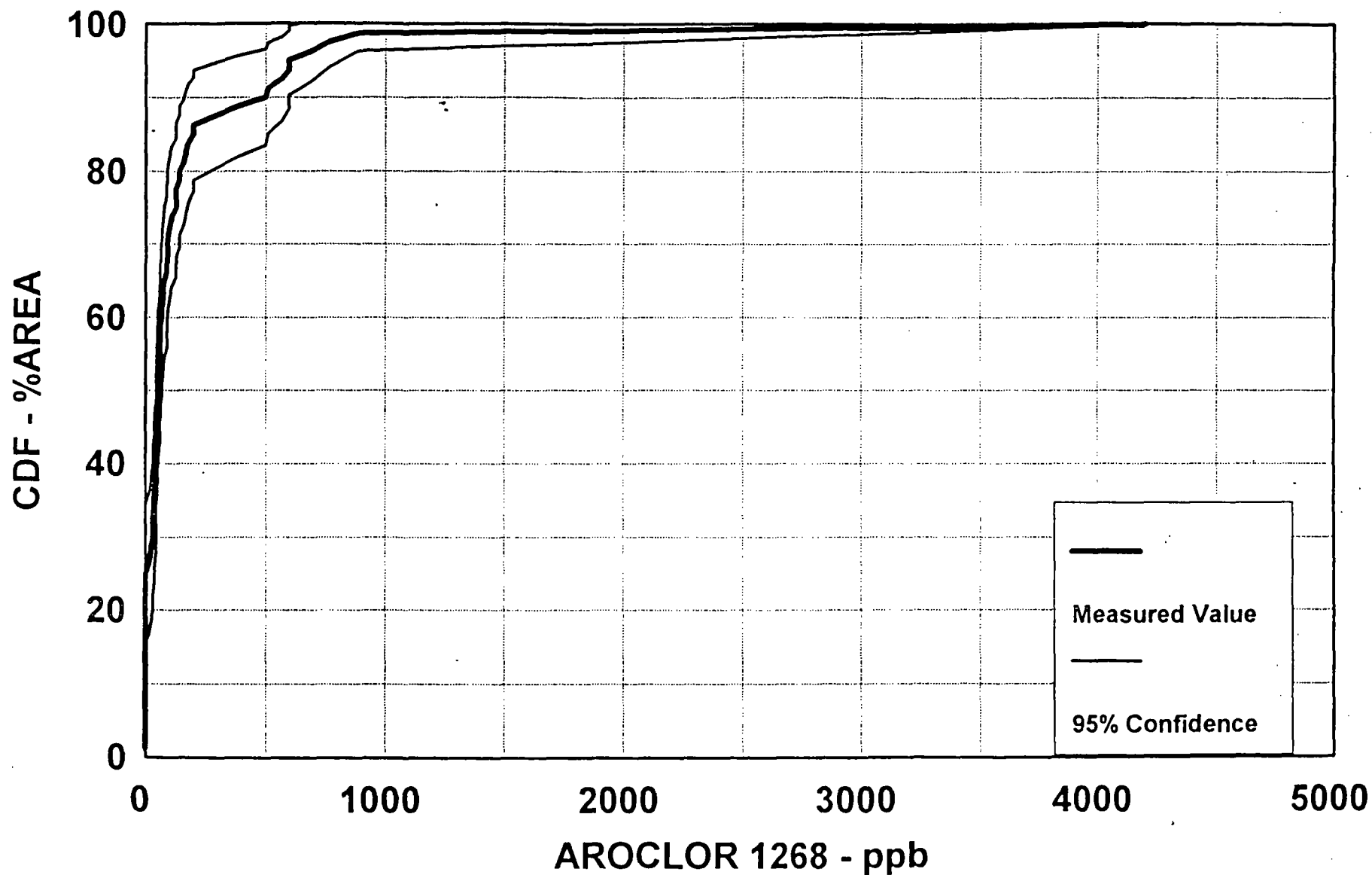
## AROCLOR 1268 IN RIVER SEDIMENT



GRAPH 34

# BRUNSWICK COMMUNITY STUDY 12/95

## AROCLOR 1268 IN MARSH SEDIMENT



GRAPH 35

## 7.0 TABLES

TABLE 1:	Sediment Toxicity Values
TABLE 2:	Target Analyte List (TAL)
TABLE 3:	Target Compound List (TCL)
TABLE 4:	Brunswick Surface Water Sampling Locations
TABLE 5:	Brunswick Tidal Marsh Sampling Locations
TABLE 6:	Data Quality Objectives (DQOs)

**TABLE 1**  
**SEDIMENT TOXICITY VALUES**

<u>Metals (mg/kg)</u>	<u>Screening(WD94)<sup>1</sup></u>	<u>NOEL<sup>2</sup></u>	<u>ER-L(94)<sup>3</sup></u>	<u>ER-M(94)<sup>3</sup></u>
Arsenic	8	8	8.2	70
Cadmium	1	1	1.2	9.6
Chromium	33	33	81	370
Copper	28	28	34	270
Lead	21	21	46.7	218
Mercury	0.1	0.1	0.15	0.71
Nickel	20.9	---	20.9	51.6
Silver	2	0.5	1	3.7
Zinc	68	68	150	410

<u>Organic Compounds (ug/kg)</u>	<u>NOEL</u>	<u>ER-L(94)</u>	<u>ER-M(94)</u>
Acenaphthene	22.0	16.00	500.00
Acenaphthylene		44.00	640.00
Anthracene	85.0	85.30	1100.00
Fluroene	18.0	19.00	540.00
2-Methyl Naphthalene		70.00	670.00
Naphthalene	130.0	160.00	2100.00
Phenanthrene	140.0	240.00	1500.00
Low Mol. Wt. PAH	250.0	552.00	3160.00
Benz (a)anthracene	160.0	261.00	1600.00
Benzo (a) pyrene	230.0	430.00	1600.00
Chrysene	220.0	384.00	2800.00
Dibenzo (a,h) anthracene	31.0	63.40	260.00
Fluoranthene	380.0	600.00	5100.00
Pyrene	290.0	665.00	2600.00
High Mol. Wt. PAH	870.0	1700.00	9600.00
Total PAH	2900.0	4022.00	44792.00
Total PCBs	24.0	22.70	180.00

1. United States Environmental Protection Agency, Region IV, Waste Management Division. 1994. Sediment Screening Values for Hazardous Waste Sites.
2. MacDonald, D.D., 1993. Development of an Approach to the Assessment of Sediment Quality in Florida Coastal Waters.
3. Long, Edward R., Donald D. MacDonald, and Sherri L. Smith. 1994. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Draft for Environmental Management.

**TABLE 2**  
**TARGET ANALYTE LIST**

Aluminum  
Antimony  
Barium  
Beryllium  
Cadmium  
Calcium  
Chromium  
Cobalt  
Copper  
Cyanide  
Iron  
Lead  
Magnesium  
Manganese  
Mercury  
Nickel  
Potassium  
Selenium  
Silver  
Sodium  
Thallium  
Vanadium  
Zinc

**TABLE 3**

**TARGET COMPOUND LIST**

**PURGEABLE ORGANIC  
COMPOUNDS**

Chloromethane  
Bromomethane  
Vinyl Chloride  
Chloroethane  
Methylene Chloride  
Acetone  
Carbon Disulfide  
1,1-Dichloroethene  
1,1-Dichloroethane  
1,2-Dichloroethene (total)  
Chloroform  
1,2-Dichloroethane  
2-Butanone  
1,1,1-Trichloroethane  
Carbon Tetrachloride  
Bromodichloromethane  
1,2-Dichloropropane  
cis-1,3-Dichloropropene  
Trichloroethene  
Dibromochloromethane  
1,1,2-Trichloroethane  
Benzene  
trans-1,3-Dichloropropene  
Bromoform  
4-Methyl-2-pentanone  
2-Hexanone  
Tetrachloroethene  
1,1,2,2-Tetrachloroethane  
Toluene  
Chlorobenzene  
Ethylbenzene  
Styrene  
Xylenes (total)

**PESTICIDES/AROCLORS**

alpha-BHC  
beta-BHD  
delta-BHC  
gamma-BHC (Lindane)  
Heptachlor  
Aldrin  
Heptachloro epoxide  
Endosulfan I  
Dieldrin  
4,4'-DDE  
Endrin  
Endosulfan II  
4,4'-DDD  
Endosulfan sulfate  
4,4'-DDT  
Methoxychlor  
Endrin ketone  
Endrin aldehyde  
alpha-Chlordane  
gamma-Chlordane  
Toxaphene  
Arochlor-1016  
Arochlor-1221  
Arochlor-1232  
Arochlor-1242  
Arochlor-1248  
Arochlor-1254  
Arochlor-1260

**EXTRACTABLE ORGANIC COMPOUNDS**  
(TABLE 3 CONTINUED)

Phenol	Dibenzofuran
bis-(2-Chloroethyl) ether	2,4-Dinitrotoluene
2-Chlorophenol	Diethylphthalate
1,3-Dichlorobenzene	4-Chlorophenyl-phenyl ether
1,4-Dichlorobenzene	Fluorene
1,2-Dichlorobenzene	4-Nitroaniline
2-Methylphenol	4,6-Dinitro-2-methylphenol
2,2'-oxybis (1-Chloropropane)	N-Nitroso-diphenylamine
4-Methylphenol	4-Bromophenyl-phenylether
N-Nitroso-di-n-propylamine	Hexachlorobenzene
Hexachloroethane	Pentachlorophenol
Nitrobenzene	4,6-Dinitro-2-methylphenol
Isophorone	N-Nitroso-diphenylamine
2-Nitrophenol	4-Bromophenyl-phenylether
2,4-Dimethylphenol	Hexachlorobenzene
bis (2-Chloroethoxy) methane	Pentachlorophenol
2,4-dichlorophenol	Phenanthrene
1,2,4-Trichloro-benzene	Anthracene
Naphthalene	Carbazole
4-Chloroaniline	Di-n-butylphthalate
Hexachlorobutadiene	Fluoranthene
4-Chloro-3-methylphenol	Pyrene
2-Methylnaphthalene	Butylbenzylphthalate
Hexachlorocyclo-pentadiene	3,3'-Dichlorobenzidine
2,4,6-Trichlorophenol	Benzo(a)anthracene
2,4,5-Trichlorophenol	Chrysene
2-Chloronaphthalene	bis (2-Ethylhexyl) phthalate
2-Nitroaniline	Di-n-octylphthalate
Dimethylphthalate	Benzo (b) fluoranthene
Acenaphthylene	Benzo (k) fluoranthene
2,6-Dinitrotoluene	Benzo (a) pyrene
3-Nitroaniline	Indeno (1,2,3-cd)-pyrene
Acenaphthene	Dibenzo (a,h)-anthracene
2,4-Dinitrophenol	Benzo (g,h,i) perylene
4-Nitrophenol	



**TABLE 4**  
**Brunswick Surface Water**  
**Sampling Locations**

STATION_ID	LAT_DMS	LONG_DMS		STATION_ID	LAT_DMS	LONG_DMS
BR001	31 15 0.2808	-81 25 6.4488				
BR002	31 13 52.1292	-81 25 52.1220				
BR003	31 13 10.6932	-81 33 45.0108				
BR004	31 12 58.3128	-81 24 7.5312		BR042	31 16 18.5808	-81 24 26.9172
BR005	31 12 49.9644	-81 34 33.1248		BR043	31 15 11.1888	-81 23 13.4808
BR006	31 11 17.0556	-81 25 42.9960		BR044	31 13 19.5924	-81 32 51.4212
BR007	31 10 40.5840	-81 27 44.8380		BR045	31 12 41.7420	-81 35 53.3040
BR008	31 10 34.0500	-81 31 46.7508		BR046	31 12 31.8456	-81 25 36.5736
BR009	31 9 55.3392	-81 25 3.2880		BR047	31 12 4.3452	-81 24 51.9408
BR010	31 9 47.2572	-81 31 33.8700		BR048	31 11 52.8252	-81 31 24.5964
BR011	31 9 12.0168	-81 34 9.3504		BR049	31 10 2.7840	-81 28 19.0344
BR012	31 8 59.0424	-81 31 6.1680		BR050	31 9 58.9356	-81 34 12.7200
BR013	31 8 13.5636	-81 25 10.2108		BR051	31 9 17.8632	-81 25 11.0568
BR014	31 7 43.3092	-81 25 35.7096		BR052	31 8 47.2164	-81 25 53.5008
BR015	31 7 37.4052	-81 29 41.0352		BR053	31 8 44.5164	-81 29 54.5604
BR016	31 7 22.1376	-81 26 26.7720		BR054	31 8 44.3904	-81 27 44.2836
BR017	31 7 3.1260	-81 29 53.7540		BR055	31 8 11.0220	-81 32 21.0300
BR018	31 6 43.0272	-81 28 48.9360		BR056	31 8 7.3608	-81 25 30.1980
BR019	31 6 24.5088	-81 25 22.3716		BR057	31 7 23.3364	-81 30 19.8972
BR020	31 5 44.8188	-81 26 2.6628		BR058	31 7 3.5436	-81 27 47.7468
BR021	31 5 8.0088	-81 26 53.4912		BR059	31 6 26.3952	-81 27 55.7172
BR022	31 15 29.4372	-81 24 8.2764		BR060	31 6 9.4248	-81 26 30.6636
BR023	31 13 40.2132	-81 35 22.7328		BR061	31 5 35.3832	-81 27 26.1756
BR024	31 13 35.6448	-81 26 42.9288		BR062	31 13 57.0144	-81 23 54.0312
BR025	31 12 46.8540	-81 25 6.6612		BR063	31 13 45.0228	-81 35 25.3788
BR026	31 11 54.4200	-81 33 2.9700		BR064	31 12 46.1772	-81 26 4.5240
BR027	31 11 53.6640	-81 26 59.1756		BR065	31 12 44.2404	-81 33 14.2920
BR028	31 11 22.9632	-81 32 9.6828		BR066	31 12 22.2372	-81 27 23.2272
BR029	31 10 57.3456	-81 25 28.0992		BR067	31 12 10.2924	-81 24 3.6036
BR030	31 10 14.6388	-81 27 3.6396		BR068	31 11 46.6872	-81 35 2.0832
BR031	31 9 26.5860	-81 31 44.6520		BR069	31 10 59.0160	-81 31 14.0988
BR032	31 9 3.5820	-81 30 32.9580		BR070	31 10 38.8812	-81 33 56.2032
BR033	31 8 52.6776	-81 32 39.0768		BR071	31 9 45.2484	-81 30 18.7272
BR034	31 8 29.0940	-81 25 51.2184		BR072	31 9 40.8708	-81 26 34.1844
BR035	31 7 34.7088	-81 25 13.1412		BR073	31 8 49.0992	-81 26 10.7124
BR036	31 7 20.7840	-81 29 23.2836		BR074	31 8 43.1376	-81 31 31.8756
BR037	31 6 55.4652	-81 30 38.0484		BR075	31 8 36.8880	-81 25 13.0008
BR038	31 6 26.0820	-81 25 42.7872		BR076	31 8 0.6864	-81 31 3.1980
BR039	31 5 36.3120	-81 26 20.9940		BR077	31 7 19.2432	-81 28 58.8216
BR040	31 4 28.1784	-81 27 37.6164		BR078	31 7 18.1776	-81 24 49.1364
BR041	31 3 41.4792	-81 25 38.1900		BR079	31 6 24.5556	-81 26 40.6428
				BR080	31 5 40.7796	-81 27 12.7764
				BR081	31 5 32.4780	-81 28 42.4560

**TABLE 5**  
**Brunswick Tidal Marsh**  
**Sampling Locations**

STATION_ID	LATDMS	LONGDMS	STATION_ID	LATDMS	LONGDMS
BM001	31 17 38.5908	-81 26 3.6888	BM041	31 10 56.8236	-81 28 9.8184
BM002	31 17 2.2524	-81 25 6.7368	BM042	31 10 52.2804	-81 33 38.6388
BM003	31 16 35.3820	-81 25 5.9520	BM043	31 10 49.2816	-81 31 55.6572
BM004	31 16 20.3952	-81 24 32.6484	BM044	31 10 42.8160	-81 25 43.4208
BM005	31 15 49.3596	-81 25 15.0456	BM045	31 10 27.4044	-81 23 42.2772
BM006	31 15 40.3884	-81 23 42.8424	BM046	31 10 25.9680	-81 26 30.7428
BM007	31 15 35.9784	-81 25 27.5700	BM047	31 10 17.4252	-81 33 50.8140
BM008	31 14 55.9572	-81 23 30.4044	BM048	31 10 6.6180	-81 27 52.6644
BM009	31 14 35.2860	-81 25 43.0860	BM049	31 9 55.2780	-81 30 44.0568
BM010	31 14 28.7520	-81 35 1.9572	BM050	31 9 50.8752	-81 27 36.0576
BM011	31 14 25.9152	-81 24 17.4204	BM051	31 9 48.9420	-81 26 15.1764
BM012	31 14 24.3888	-81 24 57.4092	BM052	31 9 45.7668	-81 28 2.4276
BM013	31 14 1.5324	-81 25 20.3592	BM053	31 9 34.6896	-81 34 22.5768
BM014	31 13 57.8712	-81 24 20.5560	BM054	31 9 31.7160	-81 25 43.6512
BM015	31 13 55.2000	-81 26 43.9980	BM055	31 9 15.7212	-81 27 20.7684
BM016	31 13 48.1044	-81 35 36.4200	BM056	31 9 10.4256	-81 25 1.5924
BM017	31 13 41.9016	-81 26 32.2368	BM057	31 8 58.9416	-81 32 8.5416
BM018	31 13 27.1452	-81 32 46.6944	BM058	31 8 58.0164	-81 33 31.7340
BM019	31 13 22.2564	-81 25 53.9292	BM059	31 8 55.1004	-81 28 20.0856
BM020	31 12 54.7920	-81 24 50.6556	BM060	31 8 36.0276	-81 30 3.5208
BM021	31 12 52.3620	-81 31 5.7072	BM061	31 8 15.8064	-81 26 27.1284
BM022	31 12 39.9024	-81 27 42.2316	BM062	31 8 13.3476	-81 32 1.7880
BM023	31 12 30.2040	-81 34 26.2920	BM063	31 8 12.7860	-81 27 50.5404
BM024	31 12 24.3036	-81 36 2.5560	BM064	31 7 55.0632	-81 28 28.2828
BM025	31 12 23.9904	-81 33 50.1768	BM065	31 7 21.6768	-81 27 18.7020
BM026	31 12 20.2356	-81 25 59.2140	BM066	31 7 13.9116	-81 28 12.5760
BM027	31 12 7.8012	-81 34 54.8004	BM067	31 7 6.2040	-81 31 17.8860
BM028	31 12 9.7668	-81 23 45.5244	BM068	31 6 39.7476	-81 30 6.1092
BM029	31 12 2.0664	-81 26 21.0840	BM069	31 6 33.9192	-81 30 44.6868
BM030	31 12 1.6884	-81 24 15.3324	BM070	31 6 13.2228	-81 25 11.0568
BM031	31 11 51.9504	-81 35 7.0512	BM071	31 6 11.1312	-81 28 55.2108
BM032	31 11 45.2328	-81 31 36.9336	BM072	31 5 37.1436	-81 25 45.2280
BM033	31 11 37.3992	-81 33 56.2716	BM073	31 5 13.1568	-81 26 54.7116
BM034	31 11 34.4976	-81 27 35.2872	BM074	31 4 58.5624	-81 26 10.5144
BM035	31 11 31.6500	-81 24 48.9492	BM075	31 4 52.0896	-81 27 38.3112
BM036	31 11 24.5040	-81 26 42.8532	BM076	31 4 48.4392	-81 26 40.6104
BM037	31 11 16.3320	-81 25 50.9376	BM077	31 4 48.0288	-81 27 18.9576
BM038	31 11 11.3676	-81 30 52.2720	BM078	31 3 44.2800	-81 26 44.7396
BM039	31 11 11.1840	-81 24 18.1080	BM079	31 3 23.8716	-81 25 51.5100
BM040	31 11 8.6892	-81 34 36.9588	BM080	31 2 54.4236	-81 25 43.2300

**TABLE 6. DATA QUALITY OBJECTIVES FOR THE COMMUNITY BASED ENVIRONMENTAL STUDY IN BRUNSWICK, GEORGIA**

<b>SURFACE WATER</b>		<b>SEDIMENT</b>	
LOCATION	Turtle and Mackay Rivers and associated tributaries	LOCATION	Turtle and Mackay Rivers and associated tributaries and marshes
SAMPLE TYPE	Environmental, Surface Water Grab from tidal river and tributaries	SAMPLE TYPE	Environmental, Grab Samples from Rivers and Creeks and associated marshes
DATA USE	Characterize Nature & Extent of Contamination	DATA USE	Characterize Nature & Extent of Contamination
DATA TYPES	A. Field Measurements - TEMPERATURE, SALINITY Field Analytical Data Level - FIELD SCREENING B. Laboratory Analyses - VOA, BNA, PESTICIDES, PCB's, METALS, ULTRA TRACE LEVELS MERCURY, CYANIDE Laboratory Analytical Data Levels - DEFINITIVE	DATA TYPES	A. Field Measurements - SEDIMENT PARTICLE PARTITIONING (excluding marshes) Field Analytical Data Level - NONE B. Laboratory Analyses - VOA, BNA, PESTICIDES, PCB's, METALS and METALS for all sediment, TOTAL ORGANIC CARBON/SEDIMENT PARTICLE SIZE for river and tributary sediment, and DIOXIN/FURANS (up to 10% of samples) Laboratory Analytical Data Levels - DEFINITIVE
FIELD QA/QC	5% Split Samples, VOA Trip Blank, Metals and Cyanide Preservative Blank, An Equipment Blank will be collected once per week or if warranted	FIELD QA/QC	5% Split or Duplicate Samples, An Equipment Blank will be collected if warranted
SAMPLING PROCEDURES	Section 4, <i>ECBSOPQAM</i> , and <i>ESBSOPM</i>	SAMPLING PROCEDURES	Section 4, <i>ECBSOPQAM</i>
BACKGROUND/CONTROL	Background/Control Samples will be collected from River and Creek Locations Upstream from the Study Area	BACKGROUND/CONTROL	Background/Control Samples will be collected from River and Creek Locations Upstream from the Study Area
<b>FISH TISSUE</b>		<b>STATION POSITIONING</b>	
LOCATION	Turtle and Mackay Rivers and associated tributaries	LOCATION	Turtle and Mackay Rivers and associated tributaries and marsh
SAMPLE TYPE	A. <i>Fundulus</i> sp. - composite, whole-body B. Commercially important species - composite, skin-on fillets including belly flap	SAMPLE TYPE	GPS coordinates of All Environmental Media
DATA USE	Characterize Nature & Extent of Contamination in Fish Tissue	DATA USE	In-field determination of geodetical positions
DATA TYPES	A. Field Measurements - NONE Field Analytical Data Level - NONE B. <i>Fundulus</i> sp. Laboratory Analyses - BNA, PESTICIDES, PCB's, METALS Commercially important species Laboratory Analyses - DIOXIN Laboratory Analytical Data Level - DEFINITIVE	DATA TYPES	A. Field Measurements - LATITUDE/LONGITUDE or NORTHING/EASTINGS Field Analytical Data Level - NONE B. Laboratory Analyses - NONE Laboratory Analytical Data Level - NONE
FIELD QA/QC	5% Split Samples. An Equipment Blank will be collected, if warranted.	FIELD QA/QC	Measurement of sample location within 100 meters of the designated coordinates of the selected station
SAMPLING PROCEDURES	Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 1. Fish Sampling and Analysis.	SAMPLING PROCEDURES	In accordance to the manufacturer's direction
BACKGROUND/CONTROL	Background/Control Samples will be collected from River and Creek Locations Upstream from the Study Area	BACKGROUND/CONTROL	Geodetic Survey Control Marker

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## APPENDICES

### APPENDIX A: SURFACE WATER DATA

- A-1: Metals
- A-2: PCBs/Pesticides
- A-3: Extractable Organic Compounds
- A-4: Purgeable Organic Compounds

### APPENDIX B: RIVER SEDIMENTS DATA

- B-1: Metals
- B-2: PCBs/Pesticides
- B-3: Extractable Organic Compounds
- B-4: Purgeable Organic Compounds
- B-5: Dioxins

### APPENDIX C: MARSH SEDIMENTS DATA

- C-1: Metals
- C-2: PCBs/Pesticides
- C-3: Extractable Organic Compounds
- C-4: Purgeable Organic Compounds

### APPENDIX D: FISH DATA

- D-1: Metals
- D-2: PCBs/Pesticides
- D-3: Extractable Organic Compounds

## APPENDICES QUALIFIER LEGEND

Many of the values in the data tables have qualifiers listed immediately after the concentration value, which help explain the concentration of a particular constituent. Following is listing and explanation of these qualifiers.

A - Average value

NA - Not Analyzed

NAI - Interferences

J - Estimated value

N - Presumptive evidence of presence of material

K - Actual value is known to be less than the value given

L - Actual value is known to be greater than the value given

U - Material was analyzed for but not detected

## APPENDIX A

### BRUNSWICK SURFACE WATER DATA

A-1: METALS

A-2: PCBs/PESTICIDES

A-3: EXTRACTABLE ORGANIC COMPOUNDS

A-4: PURGEABLE ORGANIC COMPOUNDS



## APPENDIX B

### BRUNSWICK RIVER SEDIMENTS DATA

- B-1: METALS
- B-2: PCBs/PESTICIDES
- B-3: EXTRACTABLE ORGANIC COMPOUNDS
- B-4: PURGEABLE ORGANIC COMPOUNDS
- B-5: DIOXINS

## APPENDIX C

### BRUNSWICK MARSH SEDIMENTS DATA

C-1: METALS

C-2: PCBs/PESTICIDES

C-3: EXTRACTABLE ORGANIC COMPOUNDS

C-4: PURGEABLE ORGANIC COMPOUNDS

## APPENDIX D

### BRUNSWICK FISH DATA

D-1: METALS

D-2: PCBs/PESTICIDES

D-3: EXTRACTABLE ORGANICS